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CIRCULAR NO. 43, SECOND EDITION.¹

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United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE PEA APHIS.²

(*Macrosiphum pisi* Kalt.)

By F. H. CHITTENDEN,

In Charge of Truck Crop and Special Insect Investigations.

One of the most destructive and troublesome insects of recent years is a green plant-louse which, from its injury to peas, is known as the

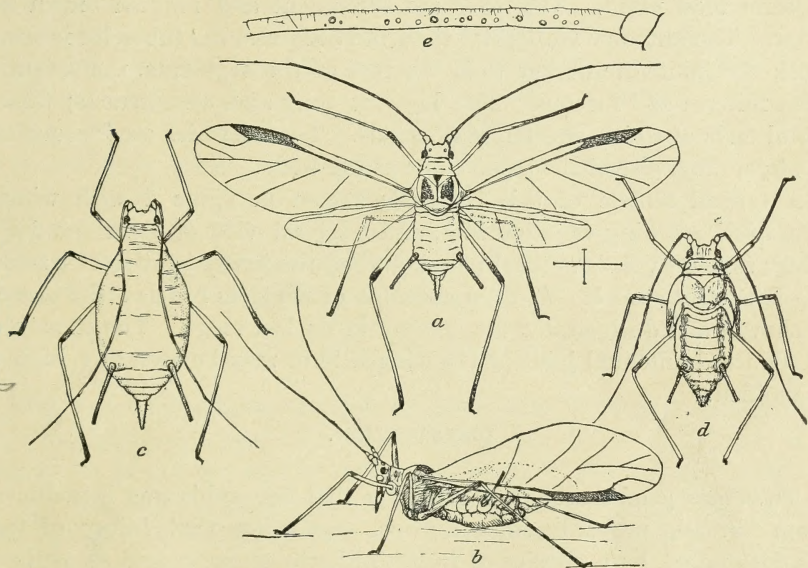


FIG. 1.—Pea aphid (*Macrosiphum pisi*): a, Winged female; b, same from side, with wings folded in natural position, as when feeding; c, apterous female; d, nymph in last stage; e, third joint of antenna of winged form. a-d, Much enlarged; e, more highly magnified. (Author's illustration.)

pea aphid. Since it first attracted attention by its ravages in May of 1899 it has steadily increased in injuriousness, and has been the cause

¹ Reprint, with slight revision, of Circular No. 43, Second Series, entitled "The Destructive Green Pea Louse (*Nectarophora destructor* Johns)."

² Several articles have been published on this insect, notably by Messrs. Johnson and Sanderson, as well as by the writer. The former gave it the scientific name *Nectarophora destructor*, but the latter gives reasons to show that this insect is in reality the European *pisi* Kalt.; hence the present change of title.

of great loss in the principal pea-growing regions of this country, especially where peas are grown for canning. It was, in fact, one of the most important of all insects that ravaged crops in the United States during the seasons of 1899 and 1900, and there appears to be little prospect, unless the unforeseen happens, of any decrease in its devastations. On the contrary, it is to be expected that it will widen its range, as it has apparently already done to some extent.

DESCRIPTIVE.

The pea aphid is one of unusual size among those found infesting gardens, and the largest of the green species which attack the pea and related plants. The length of the body of winged, viviparous females is about $\frac{3}{16}$ inch (4.5 mm.), and the total wing expanse about $\frac{4}{10}$ inch (9 to 11 mm.). The general color of both the winged and apterous or wingless forms is uniform pea-green, the same color as the insect's favorite food plant. The eyes are prominent and reddish brown in color. The antennæ are lighter than the body and the tubercles prominent; the joints are darker than the rest of the segments, the seventh joint filiform and fuscous. The legs are long and conspicuous; tarsi, distal ends of tibiæ, and femora fuscous. The nectaries are fuscous at the tips, otherwise of the same color as the body.

A typical female of this insect is shown in figure 1 with wings expanded, showing venation at *a*, and a lateral view of the same with wings folded in their natural position when the insect is at rest or feeding is presented at *b*. At *c* an apterous or wingless form of the insect is shown, and *d* illustrates the nymph in its last stage. The structure of the third antennal joint of the winged form may be seen at *e*, highly magnified.

DISTRIBUTION.

There are good reasons for believing that this aphid was introduced from abroad, probably from Europe, one being that injury of the severity noted by a species of insect hitherto unrecognized as distinct from others of its kind is almost without a parallel in the history of economic entomology. It seems probable, therefore, that we have in the pea aphid a case analogous to that of the European gipsy moth, which was present in this country for about twenty-five years before it became a pest.

The first notice of severe attack to pea that can with positiveness be attributed to the pea aphid was reported to this office, in a letter dated May 16, 1899, by Mr. Thomas Bridges, Bridges, Va. This was followed within the next few days by reports from Virginia and Maryland, and soon afterward injury was recognized in other States and in Canada. During the previous season (1898), however, this pest was present in

some numbers in certain fields in Maryland and was noticed on late peas in New Jersey.

This insect, as has been stated, was generally injurious during the years 1899 and 1900, although somewhat locally in some States, from Nova Scotia south to North Carolina and westward to Wisconsin. The insect's occurrence in destructive abundance was noted by 1900 in Nova Scotia, New Brunswick, and Ontario, Canada; Maine, Vermont, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, District of Columbia, Virginia, North Carolina, Michigan, Ohio, Illinois, and Wisconsin.¹ Sanderson has recorded the species as occurring also in Minnesota and Nebraska. Injury in Wisconsin was not noticed prior to 1900.

At intervals since 1901 this species has been injurious locally but there have been no widespread outbreaks. During the past three years the species has been rather unusually troublesome, judging by complaints. In 1906 injuries were reported in localities in New York, Virginia, Illinois, and Texas. In 1907 the range of destructiveness embraced portions of eastern, central, and western New York and parts of Maryland, Virginia, and the District of Columbia. The insect also made its initial appearance as a pest in Louisiana. In 1908 complaints were made of ravages on Long Island and in Maryland, Virginia, Pennsylvania, New Jersey, and California. In New Hampshire early peas were destroyed and in tidewater Virginia late peas were injured. It is evident from recent reports, e. g., those of injuries in Texas, Louisiana, and California, that the species is likely to be a pest any year practically throughout the United States and Canada where peas are grown.

EXTENT OF INJURY AND METHOD OF WORK.

This pea aphid during the first season of its abundance overran and laid waste fields of peas from Nova Scotia and Maine to Virginia and Maryland, in the last and in some neighboring States destroying about 50 per cent of the annual output and doing similar injury the following year, in spite of vigorous efforts that were made to control it.

An estimate of the total loss for the year 1899 in the Atlantic Coast States reached the sum of \$3,000,000. During 1900 the loss over the same area was placed, as early as June 15, at \$4,000,000. Several cases of severe damage were reported in Maryland, in which 80 per cent or more of the peas on farms of 500 or 600 acres were completely destroyed. In short, the pea growers of the Atlantic region and westward as far as Wisconsin suffered very severe losses, which gave rise to the expression that this country had been visited by a veritable scourge.

¹There is evidence that this species was observed on crimson clover in Delaware as early as 1890, and has perhaps been present along the Potomac River since, or prior to, 1886 (Bul. No. 26, n. s., Div. Ent., U. S. Dept. Agric., pp. 58, 72).

The reasons why the species has become so conspicuous a pest are threefold: *First*, because of its ravages to a crop hitherto little troubled by insect attack, if we except the pea weevil, which has always been present in gardens and fields for upwards of a century and has come to be looked upon as a necessary evil; *second*, because it is a species never before noticed, so far as records go, as having been destructive to peas in this country; *third*, because of the great difficulty that has been experienced in its treatment, pea growers during the first year of its ravages having met with almost complete failure in the remedial measures applied.

Although garden and field peas are the crops most injured by this aphid, sweet peas, red and crimson clover, as well as vetches and tares¹ are affected, and in some cases have been damaged. Attack begins on the young pea vines; the "lice" gather in clusters at first under and within the terminals, and as the leaves become covered they attack also the stems, and by their numbers and voracity sap the life of the plant. Whole areas of vines are frequently seen covered with the aphides, which in a very few weeks are able to destroy a crop. Attack is seldom noticed until May² in the more southern States in which the insect is found, and a little later in its more northern range.

The complete life history of this species is not known, but like other aphides it produces many generations each year.

According to present knowledge, the pea aphid hibernates chiefly on clover, particularly crimson clover, from Delaware southward. In the District of Columbia it winters also on vetch. From these plants the "lice" spread by flight in April and May to peas, which they attack while the vines are young.

As with other aphides, the females at certain periods produce living young. They attain maturity in from ten to fifteen days, and possibly in less time in the hottest weather. Young that were born March 4 reached maturity (winged form) March 16, or twelve days from the time of birth, and reproduced young three days later.

As an instance of the rapid reproductive powers of this insect, Professor Johnson's estimate is interesting. He found that females produce from 110 to 120 young and that in one case where aphides were observed on the first of May the fields were abandoned on account of ravages three weeks later. Calculating from the average number of

¹ A considerable number of alternate food plants has been observed for *Macrosiphum pisi* in Europe.

² In 1901 Mr. Samuel R. Haynes, Portsmouth, Va., reported the presence of this species in that locality about April 7. During the second week of May the writer found it numerous on crimson clover and vetches at Washington, D. C., and May 14 it was reported at work upon peas in the District of Columbia, near the Maryland State line.

insects produced each day, which is six, one individual would become the progenitor of 423,912 of these aphides in one season.

NATURAL ENEMIES.

The efficiency of natural agents in the destruction of aphides is so well known that it has been hoped that some one or more of the many species observed to attack the pea aphis would increase in such numbers as to have the effect of limiting its multiplication. In spite, however, of the closest observation by a number of persons, the natural enemies have been found to produce only transient relief, and this only in limited areas, as a rule late in the season after damage has been accomplished.

The present list of insects known to attack this

aphis includes seven species of ladybirds, or "ladybugs" as they are familiarly termed,¹ three species of syrphus flies,² a lace-wing fly,³ a soldier beetle,⁴ and a few minute four-winged hymenopterous parasites.⁵

The ladybirds are destructive both as beetles and larvæ; the syrphus flies only in the larval condition, which is true also of the lace-wing fly. The efficiency of the syrphus flies is greatly impaired by the presence of a braconid parasite,⁶ which is sometimes very prevalent, almost completely exterminating its hosts in many fields. Nearly all the species observed are well-known enemies of other aphides, and in fact greatly prefer as hosts the cabbage aphis and species found on weeds to the pea aphis. The spotted ladybird (*Megilla maculata* DeG.) and a lace-wing fly (*Chrysopa oculata* Say) are shown in their different stages in figures 2 and 3 respectively.

In addition to the natural enemies that have already been enumerated, several other insects attack the pea aphis, among them a small red mite, *Rhyncholophus parvus* Banks.

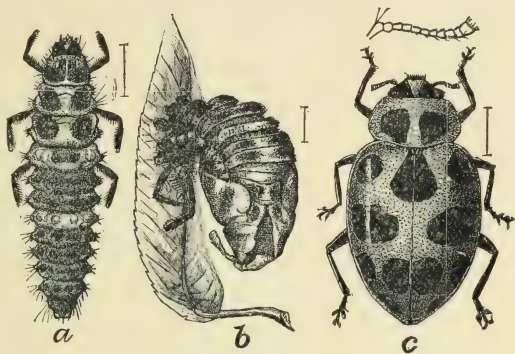


FIG. 2.—Spotted ladybird (*Megilla maculata*): a, Larva; b, empty pupal skin; c, beetle, with enlarged antenna above. All enlarged. (Author's illustration.)

¹ *Coccinella novemnotata* Hbst., *Hippodamia convergens* Guér., *Megilla maculata* DeG., *Hippodamia glacialis* Fab., *Adalia bipunctata* L., *Hippodamia 13-punctata* L., and *Coccinella sanguinea* L. ² *Allograpta obliqua* Say, *Syrphus americanus* Wied., and *Sphærophoria cylindrica* Say. ³ *Chrysopa oculata* Say. ⁴ *Podabrus rugosulus* Lec. ⁵ *Aphidius washingtonensis* (Ashm. MS.), *A. fletcheri* (Ashm. MS.), *Praon cerasaphis* Fitch, *Isocratus vulgaris* Walk. ⁶ *Bassus letatorius* Fab.

In the above list the species of each class are named in approximate order of abundance in Maryland, Virginia, and the District of Columbia, and consequent efficiency as destroyers of the aphis in that region.

Considering the inefficiency of natural agencies, if we except atmospheric conditions, in the control of this pest, it is hoped that a common fungous disease of aphides, known as *Empusa aphidis*, may become an important factor. As the development of this fungus is dependent upon rather warm, humid weather and is retarded by drought, it is fairly certain that atmospheric conditions, after all, are most important in the limitation of this insect. It is within the bounds of possibility that the fungus might be cultivated artificially and be used during weather conditions favorable in the control of this pest.

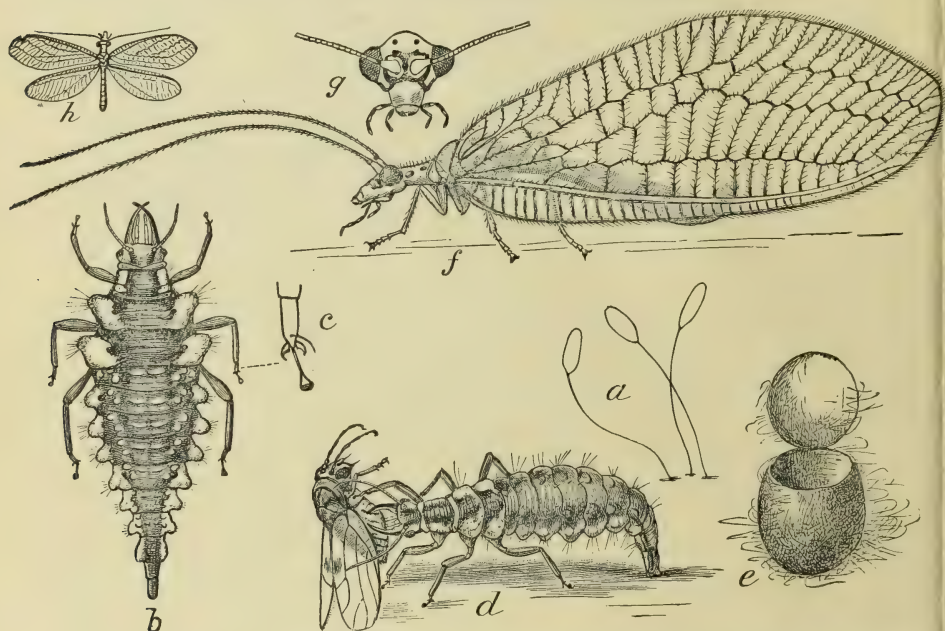


FIG. 3.—A lace-wing fly (*Chrysopa oculata*): a, Eggs; b, full-grown larva; c, foot of same; d, same devouring pear-tree psylla; e, cocoon; f, adult insect; g, head of same; h, adult. All enlarged except h, which is natural size. (From Marlatt.)

METHODS OF CONTROL.

In some instances natural enemies of the pea aphid have rendered efficient service. Seldom, however, do they destroy the insects early enough in the season to save a crop. In the course of time—many years in all likelihood—these enemies may become more effective; hence, in view of the fact that the extermination of the species even in a limited area is a practical impossibility, anything that can be done to destroy the aphid without harming its insect enemies is advisable. If this can be accomplished it will afford in itself a reason for the rejection of insecticides, none of which is in all respects satisfactory.¹

¹For the benefit of some persons who are not wholly familiar with the feeding habits of this species it should be stated that it obtains nourishment by suction, and can not therefore be reached by means of internal or stomach poisons such as Paris green and other arsenicals.

Kerosene emulsion.—Kerosene-soap emulsion, a standard remedy for aphides, carefully prepared and diluted with about twelve parts of water, sprayed upon the infested plants upon the first appearance of the aphides, and so applied that the leaves are wet on both the under and upper surfaces, has thus far been found to be the most effective of the insecticides tried. A stronger solution than that specified is apt to burn or scald the plant, particularly while the vines are young and tender. Sprays of whale-oil and other soaps have been found less useful. The cost of the kerosene emulsion remedy, however, and the difficulty of underspraying, its rapid evaporation, and the necessity for frequent applications, are such as hardly to warrant its use on a large scale.



FIG. 4.—Spraying peas with tobacco-whale-oil soap, showing method of preparation and application.

The method of preparing tobacco-whale-oil soap, a special preparation of soap of particular value for aphides, and the implements used in its application are illustrated by figure 4.

The brush-and-cultivator method.—The best remedial measure that has yet been devised is the growing of peas in rows with sufficient distance between them to admit a one-horse cultivator. The "lice" are brushed from the plants with boughs of pine with their leaves on, and a cultivator then follows down the rows as soon afterward as possible. For the perfect success of this method it should be practiced in the heat of the day, when the ground is dry and hot, and the repetition of the brushing is necessary every three to seven days until the crop is ready

for picking. Such lice as are not buried in the ground by the cultivator will be killed by the dust which closes their breathing pores, while a considerable proportion is destroyed also by the force of the brushing. This method has the advantage of not being so destructive to the natural enemies as other means that might be employed, the aphids being more fragile and delicate than any of its insect enemies. Moreover, peas planted in rows to permit of frequent cultivation suffer much less injury than when sown broadcast. As soon as the last picking has been made infested plants should be promptly destroyed by plowing under.¹



FIG. 5.—Field of peas saved by brush-and-cultivator method, showing implements used.

The brush-and-pan method.—A method which consists in jarring the aphides from the vines into specially prepared, long, shallow pans in which a little kerosene is floating, dragged between the rows, has given good results, the insects as they come into contact with the kerosene being all killed. A bushel of "lice" was caught to each row, 125 rods long, in one instance where this remedy was used. It is practicable only for small areas.

¹ We have abundant testimony to the value of this method, but perhaps none more striking than that on the farm of Mr. C. H. Pearson, a Maryland pea-grower. During the season of 1900, a 600-acre pea plantation was practically saved by this method. After other means had failed, the fields were brushed and cultivated every third day for a period of two weeks. The previous season peas over the same area were sown broadcast; so that it was impossible to combat the pest in this manner, and as a consequence 480 acres were entirely ruined. (Bul. 20, n. s., p. 94; Bul. 26, p. 57, Div. Ent., U. S. Dept. Agr.)

A field of peas saved by the use of the brush-and-cultivator method is illustrated in figure 5.

In figure 6 the manner of applying the brush-and-pan method is shown. Figures 4-7, illustrating the practical methods of combating the pea aphid, were first used by the late W. G. Johnson in an article published in Bulletin No. 26 of this Bureau.

Cultural methods.—Of cultural methods, there is testimony to the value of early planting, the earliest peas seldom being infested, or at least only slightly injured. Very large plantings of peas to be used for canning have also escaped ravages in some instances, but it may be



FIG. 6.—Field of peas saved by the brush-and-pan method, showing the apparatus used.

that atmospheric conditions have had something to do with exemption in the cases which have come under notice.

Rotation of crops is advisable, and it is unwise to plant peas on the same portion of a farm or garden, in successive years, or in the vicinity of fields of red or crimson clover, or other leguminous plants, such as vetch, which are likely to harbor this species.

As has been said, this insect passes the winter on the plants mentioned, because peas are not available, and it might be possible to use small plants of some one of them as trap crops. Crimson clover would probably be best because of its conspicuousness and the early start that it gets in the spring. On the trap plants the aphides could be killed by hand methods, such as brushing from the plants into pans,

and thus large numbers of the insects could be killed early in the season before they had opportunity to spread to peas.

In Delaware it has been shown that the practice of keeping the land well fertilized and frequently cultivated enables the peas, in spite of aphid attack, to produce better crops than would otherwise be made.

Alternate host plants.—The subject of alternate host plants is an important one, since the pea, being an annual, is not available as food for this aphid during winter. It is desirable to ascertain all of the host plants of the pea aphid, and more especially the weeds, as some one or



FIG. 7.—Section of a 600-acre pea field, rows one mile long, showing spraying outfit ready for work. Peas finally saved by brush-and-cultivator method.

more of these may be factors of importance in the life economy of the species. It might be necessary in the future, should the depredations of this insect increase, to limit the growing of clover and other legumes, as well as other alternate host plants, if such be found, in the vicinity of pea fields. If all of the principal alternate plants could be discovered this might furnish a solution of the problem of how to deal with the insect.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., January 21, 1909.

A6—49

United States Department of Agriculture,

DIVISION OF ENTOMOLOGY,

L. O. Howard, Entomologist.

THE PERIODICAL CICADA IN 1902.

The present season will witness the occurrence of one of the largest known broods of the periodical cicada (*Cicada septendecim* Linn., fig. 1). Aside from its extended range, this brood, designated as Number X (Marlatt's notation), attracts especial attention by reason of the fact that it has been observed and recorded at regular intervals of sev-

enteen years since 1715. In all seventeen States, many of which are important fruit-producing ones, will be concerned. It is well known that the adults of this insect deposit their eggs in incisions they make in the tender twigs of trees and shrubs. The damage, sometimes amounting to the actual destruction of newly transplanted young trees, that is thus caused, makes this occurrence one of consid-



FIG. 1.—a, *Cicada septendecim*, adult; b, same, side view; c, shed pupal skin; d, twig showing egg punctures—natural size (original).

erable economic importance. In fact, though the degree of danger depends somewhat upon the location of the orchard as regards the proximity of woods, any young trees transplanted this spring in the region where the cicada will appear are likely to be somewhat seriously affected. These regions are marked upon the accompanying map (fig. 2), and are indicated accurately, as far as known, by counties in the following list. It should be understood that in these localities the settlement of the country has had a strong effect toward breaking up the swarms into isolated portions. Consequently, in many places where cicadas emerged thirty-four years ago none may be seen this year. Persons contemplating the setting out of orchards should therefore ascertain from old residents whether the insects appeared in the immediate vicinity seventeen years ago. If this is the case, it is by all means advisable to defer the transplanting of trees till fall, or, if the climate does not permit fall-planting, until

the spring of 1903. In orchards the less pruning done this spring the less will be the damage the trees are likely to suffer, as this operation tends to concentrate the punctures by leaving little new growth. Likewise, wherever convenient, budding and grafting, which cause favorable places for the deposition of eggs, should be avoided.

AN EXCEPTION.

In the Connecticut valley there is a limited region where Brood XI (Marlatt's notation) will appear during the spring of 1903. This locality, which is the only one in the United States where swarms of cicadas will appear that year, includes only Hartford County in

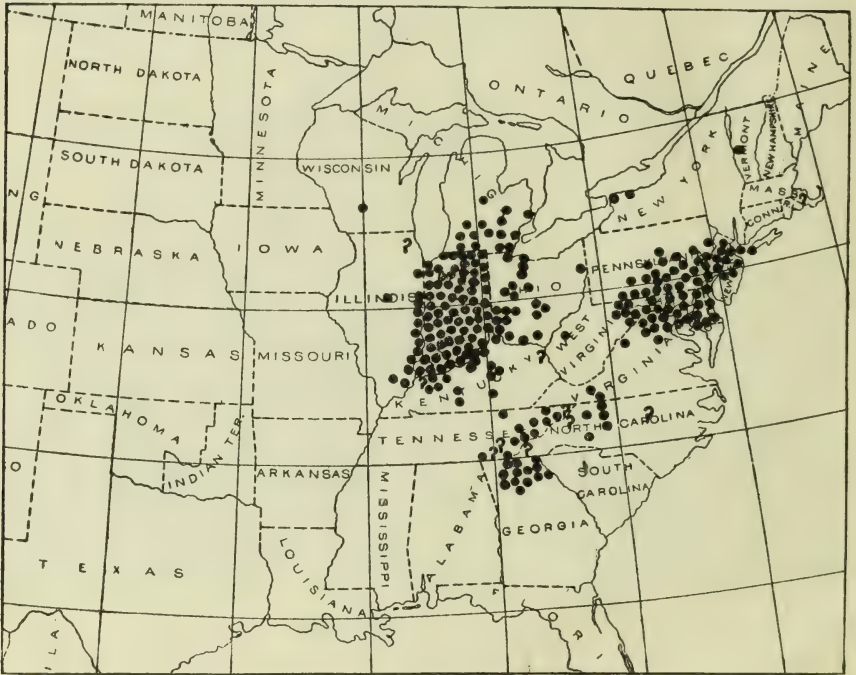


FIG.2.—Distribution of Brood X, 1902 (from Marlatt).

Connecticut and Bristol, Franklin, and Hampshire counties in Massachusetts. This brood has become scattered and is rapidly dying out. In 1886 it attracted but little attention and in 1903 will be still less in evidence. However, in places where the insects are known to have appeared in numbers in 1886 in the counties mentioned above it will be unwise to transplant trees extensively in the spring of 1903. In all other portions of the United States the year 1903 will be, as far as the periodical cicada is concerned, very favorable for tree planting, because it will be followed by a year in which, as far as is definitely known, there will be a total absence of swarms of this insect.

STATES AND COUNTIES WHERE SWARMS OF CICADAS WILL
APPEAR IN MAY, 1902.

Alabama.—St. Clair (?).

Delaware.—Kent, Newcastle, Sussex.

District of Columbia.—Throughout.

Georgia.—Banks, Dawson, Fannin, Forsyth, Franklin, Gilmer, Habersham, Hall, Lumpkin, Pickens, Rabun, Union, White.

Illinois.—Clark, Crawford, Dewitt, Edgar, Edwards (?), Gallatin, Iroquois (1868), Kane (?), Lawrence, Pope, Vermillion, Wabash, White, Williamson (perhaps Brood XXIII, Marlatt's notation).

Indiana.—Entire State except Howard, Marshall, Ohio, Porter, Pulaski, and Starke counties.

Kentucky.—Barren, Breckinridge, Carroll, Casey, Daviess, Fayette (?), Franklin, Hart (?), Henderson (?), Jefferson, Kenton, Lawrence (?), McLean, Meade, Mercer (1868), Ohio, Oldham, Trimble.

Maryland.—Alleghany, Anne Arundel, Baltimore, Caroline, Carroll, Cecil, Frederick, Garrett, Harford, Howard, Kent, Montgomery, Prince George, Queen Anne, Talbot, Washington.

Massachusetts.—Bristol (?).

Michigan.—Barry, Branch, Calhoun, Eaton, Genesee, Gratiot, Jackson, Kalamazoo, Lenawee, Livingston, Monroe, St. Clair, St. Joseph, Washtenaw, Wayne.

New Jersey.—Burlington, Camden, Hunterdon, Mercer, Middlesex, Monmouth, Morris, Passaic (?), Somerset.

New York.—Kings, Monroe, Niagara, Richmond.

North Carolina.—Caldwell (?), Cherokee (?), Davie, Lincoln (1834), Surrey, Wake (?), Wilkes, Yadkin.

Ohio.—Adams, Butler, Champaign, Clark, Clermont (?), Columbiana, Delaware, Fairfield, Franklin, Greene, Hamilton, Lucas, Miami, Montgomery, Pickaway, Pike, Preble, Sandusky, Seneca, Warren, Wyandot.

Pennsylvania.—Adams, Bedford, Berks, Blair, Bucks, Carbon, Chester, Cumberland, Dauphin, Delaware, Franklin, Fulton, Huntington, Juniata, Lancaster, Lebanon, Lehigh, Mifflin, Monroe, Montgomery, Northampton, Perry, Philadelphia, Schuylkill, Snyder, Somerset, Union, York.

Tennessee.—Blount, Carter, Hamblen, Hamilton, James (?), Johnson (?), Knox, Loudon, McMinn (?), Polk, Scott, Sevier, Sullivan, Washington.

Vermont.—Rutland.

Virginia.—Alexandria, Augusta, Carroll, Clarke and adjoining counties, Fairfax, Frederick, Loudoun, Spottsylvania (?), Warren, Wythe.

West Virginia.—Berkeley, Grant, Hardy, Hampshire and adjoining counties, Jefferson and adjoining counties, Mineral, Morgan, Putnam (?).

Wisconsin.—Sauk.

TIME OF APPEARANCE.

Though there is a little variation with the seasons, the experience of many years indicates that over the major portion of its range the bulk of the individuals of this brood will emerge from the ground during the last week in May. In Georgia and the other more southern States concerned, the time will be a trifle earlier, perhaps from the fifteenth to the twentieth of May. Naturally, however, in

any locality, a few individuals are apt to emerge some days ahead of the main swarm, and likewise some few may be retarded until early in June.

A REQUEST.

It has been the policy of this Division for many years to collect data concerning each of the several broods of this insect, with the object of eventually obtaining a basis for an accurate statement from time to time, for the benefit of fruit growers, of exactly what localities in the country will be visited by its swarms. An exceptional opportunity to more accurately determine the limits of Brood X (Marlatt) occurs this year by reason of the fact that no other broods will make their appearance in conjunction with it. At its last appearance, in 1885, this brood was associated with the thirteen-year brood, known as XXIII (Marlatt). In many districts where the territories occupied by the two were adjacent or overlapped, it was naturally impossible to assign individuals to one or the other. Likewise in 1868, the simultaneous emergence of the thirteen-year brood known as XIX (Marlatt), which will not happen again until the year 2089, caused some confusion along the Southern and Western borders. The present season, however, no such complications exist.

Persons who receive this circular will, therefore, be able to materially assist the Division by sending information as to whether swarms do or do not appear in their locality. Such information from the outlying portions of the known range and from the counties followed by interrogation marks in the preceding list is especially desired. A large number of reports, however, from within the territory known to be infested will be scarcely less valuable, because they will throw light upon the effect that the settlement of the country, the building of towns, and the removal of forests have had upon the insect.

W. D. HUNTER,

Investigator, Division of Entomology.

Approved:

JAMES WILSON,

Secretary.

WASHINGTON, D. C., *March 13, 1902.*

CIRCULAR NO. 45, SECOND SERIES.

United States Department of Agriculture,

DIVISION OF ENTOMOLOGY,

L. O. Howard, Entomologist.

LIBRARY
OF THE
UNIVERSITY of ILLINOIS.A NEW NOMENCLATURE FOR THE BROODS OF THE PERIODICAL
CICADA.

By C. L. MARLATT,

First Assistant Entomologist.

[Reprint from Bulletin No. 18, New Series, Division of Entomology, U. S. Department of Agriculture, pp. 52-58.]

The writer reviewed the different nomenclatures suggested by various authors for the broods of the periodical Cicada in Bulletin No. 14, new series, of the Division of Entomology, and therefore a brief summary of the old systems is all that need be given here.

It will be remembered that the earlier writers, viz, Prof. Nat. Potter, Dr. William T. Harris, and Dr. G. B. Smith, classified the broods solely according to the years of their appearance. The unpublished register left by Dr. Smith includes every brood now known classified according to race, and gives the localities for one additional brood, the existence of which seems not to have been confirmed. Though lacking any special designation for the broods, Dr. Smith's classification is as complete and accurate as that published by Dr. Riley and since followed by all later writers. Dr. Asa Fitch was the first to introduce a numbering system for the different broods, enumerating nine altogether, but his data were very limited and he was not aware of the 13-year southern period, and there necessarily resulted no little confusion of the broods of the two races. The Walsh-Riley enumeration of 1878 gave the records for sixteen broods, which were designated by Roman numerals from I to XVI, the enumeration being based on the sequence of the different broods after 1868. In 1869, in his First Missouri Report, Dr. Riley, having in the meantime secured the manuscript paper of Dr. Smith, added the six broods from this paper not represented in the Walsh-Riley enumeration, increasing the number of the broods to XXII, and renumbered them again in accordance with their sequence, beginning with 1869. Several of these broods are rather unimportant, or lack confirmation, and one of them, Brood III, was founded on an erroneous record and has been dropped.

In the enumeration of the broods by Walsh-Riley, and later by Riley, the two races are mixed together and a sequence of numbers given which, after the first thirteen years, lost all significance as a record of the order of the broods in time of appearance, and from the first obscured the true kinship of the broods in each race. If, on the other hand, each race be considered separately and its broods be

arranged in a series in accordance with their sequence in time, an important natural relationship in point of origin and distribution is plainly indicated.

Taking first the broods of the 17-year race, it will be seen from the subjoined table that if the enumeration begin with Brood XI, the 17-year broods follow each other in regular succession for eleven consecutive years; then after a break of one year follows Broods V and VIII, and after another break of one year, Brood IX; another break of one year precedes the next recurrence of Brood XI, with which the series starts.

Chronological order of the broods of the Cicada from 1893 to 1910.

Year.	17-year race.	13-year race.	Year.	17-year race.	13-year race.
1893.....	XI	XVI	1902.....	XXII	-----
1894.....	XII	XVIII	1903.....	I	-----
1895.....	XIII	II	1904.....	-----	-----
1896.....	XIV	IV	1905.....	V	-----
1897.....	XV	VI	1906.....	VIII	XVI
1898.....	XVII	VII	1907.....	-----	XVIII
1899.....	XIX	-----	1908.....	IX	II
1900.....	XX	-----	1909.....	-----	IV
1901.....	XXI	X	1910.....	XI	VI

Taking up the 13-year broods in the same way, it will be seen that if the enumeration start with Brood XVI, a 13-year brood follows in regular succession for six years. With the exception of the very doubtful Brood X, which is separated from the last 13-year brood by three years, there follow seven successive years in which no 13-year broods occur.

Under the supposition that the different broods of the 17-year and 13-year races sprang in the remote past from an original brood of each, it would naturally follow that the broods most closely related in time would also present a closer relationship in their range, and this, in fact, proves to be generally true.

To show this relationship and to indicate the natural order of their occurrence, I have to suggest a new enumeration of the broods in which the two races are separated—the 17-year broods coming first, followed, for convenience merely, by the 13-year broods. Thus Brood XI of the 17-year race becomes Brood I, and the others are numbered in the regular order of their occurrence, except that I have assigned a brood number to each of the seventeen years. This leaves Broods XII, XV, and XVII, as newly numbered, without any definite colonies, so far accepted, as representatives of established broods. As will be shown later, however, there are records which indicate the existence of small or scattering broods filling the three gaps mentioned in the 17-year series.

In the renumbering the broods of the 13-year race I have continued for convenience from the end of the series of the 17-year race, the first 13-year brood becoming Brood XVIII, and I have assigned

brood numbers to each year of the 13-year period, making a total enumeration of the broods of both races of XXX. As already indicated, six of the numbers given to the 13-year race have had no brood assigned to them, although records have been secured which seem to indicate the existence of scattering broods filling some of the gaps, as will be noted in the records given further on.

It does not necessarily follow, in fact it is quite unlikely, that Brood I, as here designated, is the original or oldest brood of the 17-year race. Undoubtedly some of the 17-year broods, perhaps half or more of them, originated by retardation of individuals, and perhaps half by acceleration of individuals; so that the original brood, if it still exists, is more likely to be one of the intermediate ones. Brood X, being the largest of the 17-year broods, perhaps has best claim to this distinction.

For the same reasons an intermediate brood in the 13-year series is doubtless the original brood of the 13-year race, and this title may possibly belong to Brood XIX which has the widest range of all the broods of the 13-year race. The fewer number of broods in this race would seem to indicate that it is of later origin than the 17-year race, and this belief is further justified by the fact of its occupying, in the main, a territory of later geographical formation.

The following table, beginning with 1893, when the initial broods of both the 17-year and the 13-year series appeared in conjunction, illustrates the new nomenclature suggested, and in parallel columns also are given the corresponding nomenclatures proposed by Professor Riley, by Walsh and Riley, by Fitch, and the year records in Dr. Smith's register:*

Nomenclature of the broods of the periodical Cicada.

Year.	Broods of the 17-year race.					Broods of the 13-year race.				
	Proposed enumeration.	Riley num-bers.	Walsh-Riley num-bers.	Fitch num-bers.	Smith regis-ter.	Proposed enumeration.	Riley num-bers.	Walsh-Riley num-bers.	Fitch num-bers.	Smith register.
1893	I	XI			1842	XVIII	XVI			1854
1894	II	XII	VIII	1	1843	XIX	XVIII	XIII	3	1842-1855
1895	III	XIII	IX		1844	XX	II			1843
1896	IV	XIV	X		1845	XXI	IV			1844
1897	V	XV	XI		1846	XXII	VI	IV		1845
1898	VI	XVII	XII	7	1847	XXIII	VII	V	5	1846-1859
1899	VII	XIX			1848	XXIV				
1900	VIII	XX	XIV	2-8	1849	XXV				
1901	IX	XXI	XV	5	1850	XXVI	X			1849
1902	X	XXII	XVI	4	1851	XXVII				
1903	XI	I	I	9	1852	XXVIII				
1904	XII		II		1853	XXIX				
1905	XIII	V	III	6	1854	XXX				
1906	XIV	VIII	VI	3	1855	XVIII	XVI			1854
1907	XV					XIX	XVIII	XIII	3	1842-1855
1908	XVI	IX	VII			XX	II			1843
1909	XVII					XXI	IV			1844

* In Bul. 14, Div. Ent., U. S. Dept. of Agr., the Riley numbers given in column 2 were employed, and should be corrected to the later enumeration indicated in column 1.

THE RELATIONSHIP OF THE DIFFERENT BROODS.

As a rule the relationship of the broods in point of distribution agrees with their kinship as indicated by their sequence in time of appearance. The relationship indicated by the latter, viz, their sequence in time, is doubtless untrustworthy as indicating origin, in some instances, on account of the uncertainty arising from the action of the principle of retardation on the one hand and acceleration on the other in the forming of new broods.

In the case of a widely scattered brood, like Brood VI, it is quite possible that certain swarms originated from a later-appearing brood by retardation of individuals, and other swarms from an earlier brood by acceleration in time of appearance of individuals.

This same condition may be true of other of the more scattered broods, but with the broods presenting a compact range a singleness of origin is evident.

Examination of the distribution of the broods in connection with their sequence in time of appearance indicates, however, a certain relationship between the different broods in point of origin, which may be indicated as follows:

THE RELATIONSHIP OF THE 17-YEAR BROODS.

From the standpoint of distribution the broods of the 17-year race may be grouped as follows: (1) Broods I and II; (2) Broods III and IV; (3) Brood V; (4) Brood VI; (5) Broods VII, VIII, IX, X, and XI; (6) Broods XII, XIII, XIV, and XV; (7) Broods XVI and XVII, the last connecting again with Brood I.

Taking up these broods in regular order:

The main body of Brood I occupies territory immediately west of the more important Brood II, and also presents a number of colonies extending westward to Colorado. Broods I and II seem, therefore, closely allied in point of origin.

Brood III presents little, if any, relationship to Brood II in point of location and distribution, but is closely allied to the following brood, IV, and the latter is evidently a western and southern extension of III.

Brood V presents little relationship with Brood IV in point of distribution and covers a very compact territory.

Brood VI, being a widely scattered one, and occurring usually in small numbers, does not seem to present any particular relationship with any of the preceding or following broods.

Brood VII is local in distribution and not very important, and is divided into two sections by the territory occupied by the following Brood VIII, with which it thus seems to be closely allied. Brood IX is very distinctly a southern extension of Broods VII and VIII.

These three broods seem, therefore, to be closely allied in their origin, and, curiously enough, occupy territory which divides the two main sections of the great 17-year Brood X, which next follows in regular succession. Brood XI, following X, is evidently an extreme northeastern extension of the latter.

Brood XII, immediately preceding XIII, is represented by a series of colonies connecting the western Brood XIII with group 5. Brood XIII is the principal representative of group 6 and represents a large western group of the 17-year race of group 6, which comprises the main western branch of the 17-year race, as group 5 clustered about X is the principal representative of the eastern branch of the same race. Brood XIV has a very wide range to the eastward of XIII, and connects with the latter through the colonies in northern Illinois and Indiana. Brood XV, following XIV, is limited to the Atlantic seaboard with the exception of one doubtful colony in Indian Territory, and connects directly with the eastern colonies of XIV.

Brood XVI is based on somewhat doubtful records, the Colorado locality perhaps being due to confusion with some other species, and the other records needing confirmation. Brood XVII is intermediate between Brood XVI and Brood I, its western colonies connected with the former and the eastern colonies with the latter.

THE RELATIONSHIP OF THE 13-YEAR BROODS.

The broods of the 13-year race break up into the following natural groups: (1) Related closely to Brood XIX, and comprising Broods XVIII, XIX, and XX; and (2) related to Brood XXIII, and comprising Broods XXI, XXII, XXIII, and our new Brood XXIV.

The first of these broods, Brood XVIII, is a rather insignificant one and is undoubtedly an eastern extension or offshoot of the great 13-year Brood XIX, which succeeds it. Brood XX is undoubtedly a section of Brood XIX retarded one year, just as Brood XVI is an accelerated swarm of the same. Both represent eastern extensions of the parent brood.

Brood XXI, separated from Brood XIX by two years, seems to bear little relationship to the latter, and a more logical arrangement consists in connecting it with Brood XXIII through Brood XXII, of which last it may be considered as an eastern and northern extension. Brood XXII is a very marked instance of the formation of a new brood by an acceleration in time of the appearance of a portion of a larger and older brood. Its relationship with Brood XXIII is very marked and can not be questioned. Brood XXIII, the main representative of this group, is followed by the new Brood XXIV, which is evidently a retarded swarm of the preceding brood.

Of the new Broods XXIX and XXX, both of which need verification, no significant relationship can be pointed out.

Brood XXIX is very doubtful, and the records are possibly based on confusion with the 17-year race.

NEW BROODS 17-YEAR RACE.

Brood XII, 1904.—If his records are correct, this brood is the one referred to by Dr. G. B. Smith as occurring in 1853 in Vinton County, Ohio, and Jo Daviess County, Ill. Its recurrence seems not to have been recorded either in 1870 or 1887, and Smith's records are therefore open to question.

Mr. J. R. Burke, Milton, Cabell County, W. Va., writing under date of May 22, 1897, says: "The Cicada is not due here until 1904; its last visit was in 1887."

Mr. W. S. Herrick, Thurman, Allen County, Ind., writes under date of June 10, 1898, that "We had the 17-year locust in 1887, if I remember correctly." This is also a doubtful record, and it is possible that he referred either to Brood XXII, occurring in 1885, or Brood V, occurring in 1888.

That all these records are open to some doubt is apparent, but they are of sufficient importance to warrant investigation in 1904.

Brood XV, 1907.—This brood is represented by the colony appearing at Tivoli, Dutchess County, and Galway, Saratoga County, N. Y., in June, 1890, as recorded by Prof. J. A. Lintner in his Seventh Report, pages 297-301. Mr. Davis records the occurrence of scattering individuals the same year on Staten Island. In a letter of June 2, 1890, Prof. J. B. Smith, New Brunswick, N. J., reports that the periodical Cicada had been taken by several Newark collectors, and had also been observed at Anglesea, Cape May County.

Another record which perhaps applies to this brood is given by Mr. I. N. Smith, Scotland Neck, Halifax County, N. C., in letter of June 22, 1885. He reports that his "First recollection of the locust was about the year 1839 or 1840, when the whole of the white-oak lands were filled with them. * * * In 1855 or 1856 they appeared again, but nothing to compare with the period first stated. The locusts were all on the white-oak land and on the Roanoke River and not on the pine lands." Assuming the dates 1839 and 1856 to be the correct ones, this would throw this swarm of Cicadas into Brood XV, and if there are any representatives left they should reappear in 1907.

The late Mr. W. S. Robertson, of Muscogee, Ind. T., in a letter of June 17, 1879, incidentally mentioned also the occurrence of a brood of Cicadas 1839. This record could not fall in any one of the old broods, and if it belongs to the 17-year race it would be an extreme western outpost of XV.

Brood XVII, 1909.—A very definite record which may coincide with this brood is furnished by Mr. Theodore Pergande, of this Division, who states that Mr. Rosseau, of Charlottesville, Albemarle

County, Va., informed him that the Cicada was very numerous in that place in 1875. His informant was positive as to the year from its being the one in which he made a trip to Europe.

Another record is given by Mr. John D. Macpherson, Manassas, Prince William County, Va., in letter of July 3, 1895. He writes: "I came here on the 23d of June, leaving the Cicada in full song in Washington (Brood X). Finding none here, I made inquiry and was informed that they appeared in full force in this county (Prince William) in the year 1875. This information I regard as reliable, the date being fixed as the year following the marriage and arrival of my informant in this county." These Virginia swarms are evidently precursors of Brood I, with which they are therefore closely allied.

A western extension of this brood seems to be indicated in the record furnished by H. J. Giddings, Sabula, Jackson County, Iowa. He writes, "during last June (1892) the periodical Cicada was quite common here. * * * I thought it was unusual to find them in such numbers four years after their regular appearance. The last regular year was 1883." (See *Insect Life*, Vol. V, page 200.)

If belonging to the 17-year race, the two records following should also be assigned to this brood. Mr. A. J. Julian, Woolleys Ford, Hall County, Ga., reports under date of June 14, 1898, that the Cicada was present there in 1892. Mr. J. W. Seaton, Strasburg, Cass County, Mo., writes under date of June 9, that the Cicada last appeared in that county in the summer of 1892 and in the summer of 1896, being numerous both years. The 1896 record refers to the 17-year Brood IV, and hence the record of 1892 is probably also of the 17-year race occurring in the same district.

The scattering specimens recorded by Mr. Davis as occurring on Staten Island in 1892 may also be assigned to this brood.

NEW BROODS, 13-YEAR RACE.

Brood XXIV, 1899.—Mr. P. Lynch, Commerce, Scott County, Mo., under date of December 24, 1874, reports that the Cicada appeared in the summer of 1873 in considerable numbers, coming in June and remaining about two months. "Their eastern limit in this county (Scott) was the Mississippi River, but they were as numerous on the opposite side of the river in Alexander County, Ill."

Mr. W. S. Campere, Pickens Station, Holmes County, Miss., writes under date of February 27, 1875, that the Cicadas appeared in great numbers in April, 1873. These two records would indicate a brood originating doubtless by retardation of individuals of Brood XXIII.

Brood XXIX, 1894.—It is possible that the following records apply to a 13-year race, and in that case should be assigned to our Brood No. XXIX.

Mr. C. J. Wellborn, Blairsville, Union County, Ga., writes under date of June 12, 1885, that "in May, 1878, locusts appeared south of this place and the northern limit then was the present southern limit of the territory covered now (by Brood X, 1885)."

Mr. James Pagon, Winnsboro, Fairfield County, S. C., writes that locusts appeared in South Carolina in 1878, but does not give definite localities. Both these records need confirmation.

Brood XXX, 1905.—Mr. B. H. Brodnax, Brodnax, Morehouse Parish, La., writes under date of May 13, 1892, that Cicadas are scatteringly present, and in a later letter he asserts that the insect in question is the periodical Cicada, with which he is familiar.

The records given above of new broods of the 13-year race are rather unsatisfactory, and it may be true that the 13-year race has not by any means distributed itself over its entire period, and the broods still cluster about the two main representatives of the race, namely Broods XIX and XXIII.

WASHINGTON, D. C., *May 1, 1902.*

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

HYDROCYANIC-ACID GAS AGAINST HOUSEHOLD INSECTS.

By L. O. HOWARD.

Hydrocyanic-acid gas is one of the most effective remedies known against various classes of insects. For more than twenty years it has been the principal means of controlling scale insects on citrus trees in California and is now in general use for the disinfection of all deciduous nursery stock and other plant material for shipment, and is also one of the most effective methods of ridding greenhouses and cold frames of plant-lice, thrips, white fly, and various scale pests which infest plants grown under glass.²

It has been fully demonstrated that this gas, which is very deadly to all forms of animal life, is, under proper precautions, an excellent remedy for household insects. Probably its first use for this purpose was in June of 1898 by Mr. Marlatt, of this office, against book-lice in the residence of an employee of the Department of Agriculture, using the cyanide first at the ordinary strength employed on fruit trees, then double, and finally quadruple the strength. The book-lice came from recently introduced leather-covered furniture, the covering of which was so tightly fastened as to be almost, if not quite, impervious to the gas, and the treatment was only partially successful. Another early use of this gas for household insects was in 1899 in San Francisco by Mr. Alexander Crow, Chief Quarantine Officer of the Board of Horticulture. In this case it was used against bedbugs and in very small proportions. Two and one-half fluid ounces of commercial sulphuric acid and 2½ ounces 98 per cent cyanide of potassium were used in a house of several rooms, each containing about 2,250 cubic feet of space. The rooms were closed for two hours, then entirely aired. The operation was apparently successful.

Perfectly successful experiments were made during the summer of 1901 by Mr. W. R. Beattie, of the Department of Agriculture, and by Mr. A. H. Kirkland, of Boston, Mass., formerly Secretary of the Association of Economic Entomologists. Mr. Beattie's experiments were against cockroaches and Mr. Kirkland's in one case against fleas and in the other against clothes moths.

¹ Revised by C. L. Marlatt, Entomologist and Acting Chief in Absence of Chief.

² Refer to Circulars 37, 42, and 57, and Farmers' Bulletin 172.

Entomologists have long noticed that insects vary greatly in their susceptibility to cyanide fumes. The ordinary killing bottle used in making collections contains cyanide of potassium covered with plaster of Paris, which the fumes of the cyanide penetrate. Certain weevils, and especially such weevils as *Lixus* and *Sphenophorus* and other hard-bodied forms, will frequently be left overnight in a cyanide bottle and recover after being removed. It has been noticed also that in greenhouses certain insects recover. The experience gained, however, indicates that the use of hydrocyanic-acid gas in houses is successful against cockroaches, bedbugs, fleas, clothes moths, ants, white ants, house flies, and other soft-bodied insects; and as these constitute the majority of the household pests, the use of the gas must now be considered a standard remedy. Moreover, rats and mice are also killed by its use, and it fortunately has the effect of first causing these animals to rush out from their holes into the open, so that the subsequent annoyance of dead mice in walls and under floorings is not experienced.

Since the initial experiment against household pests in 1898 a great deal of experience has been gained in practical work by this Bureau. Many residences and public buildings and offices of this Department, stores, and schools have been fumigated, especially since 1901. This work has been conducted chiefly under the direction of Mr. Marlatt by Messrs. Busck, Pratt, Kotinsky, J. H. Beattie, and other members of the office force, and has given practically uniform success. Most of this work was done subsequent to the publication of Circular 46, second series, and is the basis for the present revision of that circular, which, however, has not been changed in essential details.

Some entomologists recommend as a substitute for hydrocyanic-acid gas a substance which has been more or less effectively used, viz, carbon bisulphid. The great danger in the use of this latter substance, however, from its extreme inflammability and the explosiveness of its vapor when confined, renders it perhaps less available and more than counteracts the danger to human beings from the use of the hydrocyanic-acid gas.¹

¹To determine the availability of hydrocyanic-acid gas against the insect enemies of stored products or in granaries, some experiments were made during 1898 and the spring of 1899 by Messrs. Marlatt and Chittenden, of this office, in the presence of Mr. D. G. Fairchild and others, against certain grain weevils and the Angoumois grain moth, but with imperfect success, although the proportions used were much greater than in Mr. Craw's experiment. In his recent book on fumigation methods, Prof. W. G. Johnson states that he used the hydrocyanic-acid gas in a granary and storehouse in June, 1899, using it at the rate of 0.1 gram of cyanide per cubic foot of space. The granary was affected by weevils, and, from the report of the owner, it appears that most of the latter were destroyed, though many escaped. During the same month in an Ohio mill another experiment of this kind was carried on under Professor Johnson's instructions. The owner considered the experiment to be "a most grand success." The Mediterranean flour moth and certain granary beetles were destroyed. There is still some doubt, however, as to its efficiency under granary and mill conditions, and further experimentation is needed.

(2) Arrange for the opening of doors and windows from the outside at the conclusion of the fumigation, and close all registers, fireplaces, and other openings. Do necessary calking and remove carpets and rugs and moist food material and any metallic objects which are likely to be tarnished.

(3) Place the generating vessels in each room with a thick carpeting of old newspapers under each.

(4) Break up the cyanide out of doors and place it in thin paper sacks containing a pound or a half pound each, suited to the amounts to be used in the different rooms.

(5) Measure into each of the generating jars the proper amount of water, and afterwards add the acid slowly in the proper amount to each of the jars.

(6) Take the cyanide in bags in a basket and place the bags to the proper amount alongside of the generating jars in each room.

(7) Start at the top of the house and place the cyanide gently, so as not to spatter, into each jar, and quickly leave the room. As soon as the upper floor is finished go to the next lower, and pass in this manner from floor to floor until the basement is reached and exit is made through the lower door. If two persons work together in this operation, they should both be on the same floor together, taking different rooms.

(8) The following day, or after the completion of the fumigation, open the windows and doors from the outside, and let the house ventilate for an hour before entering it.

(9) After the house is thoroughly ventilated and the odor of the gas has disappeared, the jars should be emptied in a safe place, preferably through the sewer trap, and thoroughly and repeatedly washed before being used for any household purpose.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *January 30, 1907.*

United States Department of Agriculture,

DIVISION OF ENTOMOLOGY,

L. O. HOWARD, Entomologist.

THE BEDBUG.

(*Cimex lectularius* Linn.)

By C. L. MARLATT,

First Assistant Entomologist.

[Revised reprint from Bulletin No. 4, New Series, Division of Entomology, U. S. Department of Agriculture, pp. 32-38.]

The presence of this insect (fig. 1) in a house is not necessarily an indication of neglect or carelessness; for, little as the idea may be relished, it may often gain access in spite of the best of care and the adoption of all reasonable precautions. It is very apt to get into

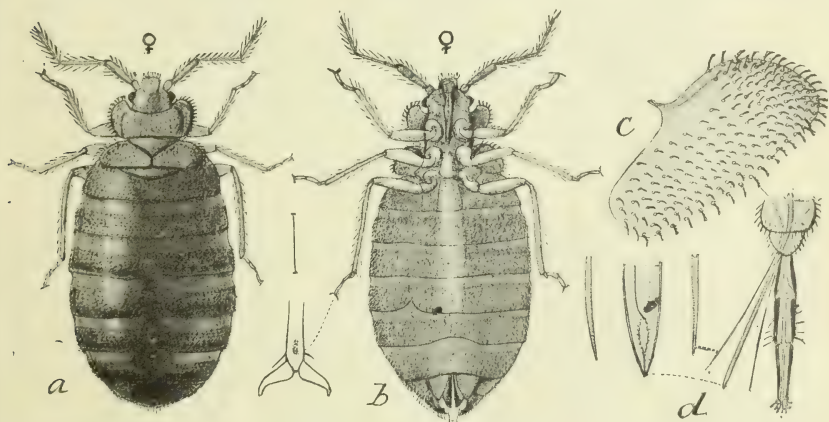


FIG. 1.—*Cimex lectularius*: a, adult female, gorged with blood; b, same, from below; c, rudimentary wing-pad; d, mouth-parts—all enlarged (original).

the trunks and satchels of travelers, and may thus be introduced into homes. Unfortunately, also, it is quite capable of migrating from one house to another, and will often continue to come from an adjoining house, sometimes for a period of several months, gaining entrance daily. Such migration is especially apt to take place if the human inhabitants of an infested house leave it. With the failure of their usual source of food, the migratory instinct is developed; and, escaping through windows, they pass along walls, water pipes, or gutters, and thus gain entrance into adjoining houses. In these

or other ways it may be anyone's misfortune to have his premises temporarily invaded.

As with nearly all the insects associated with man, the bedbug has had the habits now characteristic of it as far back as the records run. It was undoubtedly of common occurrence in the dwellings of the ancient peoples of Asia. The Romans were well acquainted with it, giving it the name *Cimex*. It was supposed by Pliny (and this was doubtless the common belief among the Romans) to have medicinal properties, and it was recommended, among other things, as a specific for the bites of serpents. It is said to have been first introduced into England in 1503, but the references to it are of such a nature as to make it very probable that it had been there long previously. Two hundred and fifty years later it was reported to be very abundant in the seaport towns, but was scarcely known inland. It has been inferred that the following reference from the old English Bible of 1551 is to this insect: "Thou shalt not nede to be afriad for eny Bugges by night" (Psalm XCI, 5).

One of the old English names was "wall-louse." It was afterwards very well known as the "chinch," which continued to be the common appellation for it until within a century or two, and is still used in parts of this country. The origin of the name "bedbug" is not known, but it is such a descriptive one that it would seem to have been very naturally suggested. Almost everywhere there are local names for this parasite, as, for illustration, around Boston they are called "chintzes" and "chinchies," and from Baltimore comes the name "mahogany flat," while in New York they are styled "red coats."

The bedbug has accompanied man wherever he has gone. Vessels are almost sure to be infested with it. It is not especially limited by cold, and is known to occur well north. It probably came to this country with the earliest colonists, at least Kalm, writing in 1748-49, stated that it was plentiful in the English colonies and in Canada, though unknown among the Indians.

The bedbug belongs to the order Hemiptera, which includes the true bugs or piercing insects, characterized by possessing a piercing and sucking beak. The bedbug is to man what the chinch bug is to grains or the squash bug to cucurbs. Like nearly all the insects parasitic on animals, however, it is degraded structurally, its parasitic nature and the slight necessity for extensive locomotion having resulted, after many ages, doubtless, in the loss of wings and the assumption of a comparatively simple structure. The wings are represented by the merest rudiments, barely recognizable pads, and it lacks the simple eyes or ocelli of most other true bugs. In form it is much flattened, obovate, and in color is rust red, with the abdomen more or less tinged with black. The absence of wings is a most

fortunate circumstance, since otherwise there would be no safety from it even for the most careful and thorough of housekeepers. Some slight variation in length of wing pads has been observed, but none with wings showing any considerable development have ever been found.

A closely allied species is a parasitic messmate in the nests of the common barn or eaves swallow in this country, and it often happens that the nests of these birds are fairly alive with these vermin. The latter not infrequently gain access to houses and cause the housekeeper considerable momentary alarm. At least three species occur also in England, all very closely resembling the bedbug. One of these is found in pigeon cotes, another in the nests of the English martin, and a third in places frequented by bats. What seems to be the true bedbug, or at best a mere variety, also occurs occasionally in poultry houses.¹

The most characteristic feature of the insect is the very distinct

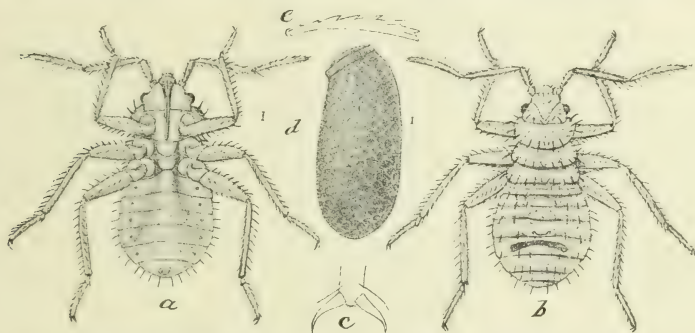


FIG. 2.—*Cimex lectularius*. Egg and newly hatched larva of bedbug: a, larva from below; b, larva from above; c, claw; d, egg; e, hair or spine of larva—greatly enlarged; natural size of larva and egg indicated by hair lines (original).

and disagreeable odor which it exhales, an odor well known to all who have been familiar with it as the “buggy” odor. This odor is by no means limited to the bedbug, but is characteristic of most plant bugs also. The common chinch bug affecting small grains and the squash bugs all possess this odor, and it is quite as pungent with these plant-feeding forms as with the human parasite. The possession of this odor, disagreeable as it is, is, after all, a most fortunate circumstance, as it is of considerable assistance in detecting the presence of these vermin. The odor comes from glands, situated in various parts of the body, which secrete a clear, oily, volatile liquid. The possession of this odor is certainly, with the plant-feeding forms, a means of protection against insectivorous birds, rendering these insects obnoxious or distasteful to their feathered enemies. With the bedbug it is probably an illustration

¹ Insect Life, Vol. VI, p. 166, Osborn.

of a very common phenomenon among animals, the persistence of a characteristic which is no longer of any especial value to the possessor of it. The natural enemies of true bugs, against which this odor serves as a means of protection, in the conditions under which the bedbug lives, are kept away from it; and the roach, which sometimes feeds on bedbugs, is evidently not deterred by the odor, while the common house ant, which will also attack the bedbug, seems not to find this odor disagreeable.

The bedbug is thoroughly nocturnal in habits and displays a certain degree of wariness and caution, or intelligence, in its efforts at concealment during the day. It thrives particularly in filthy apartments and in old houses which are full of cracks and crevices in which it can conceal itself beyond easy reach. It usually leaves the bed at the approach of daylight to go into concealment either in cracks in the bedsteads, if it be one of the old wooden variety, or behind wainscoting, or under loose wall paper, where it manifests its gregarious habit by collecting in masses together. The old-fashioned heavy wooden bedsteads are especially favorable for the concealment and multiplication of this insect, and the general use in later years of iron and brass bedsteads has very greatly facilitated its eradication. They are not apt to be very active in winter, especially in cold rooms, and ordinarily hibernate in their places of concealment.

The bedbug, though normally feeding on human blood, seems to be able to subsist for a time at least on much simpler food, and in fact the evidence is pretty conclusive that it is able to get more or less sustenance from the juices of moistened wood, or the moisture in the accumulations of dust, etc., in crevices in flooring. No other explanation would seem to account for the fact that houses long unoccupied are found, on being reinhabited, to be thoroughly stocked with bedbugs.

There is a very prevalent belief among the old settlers in the West that this insect normally lives on dead or diseased cottonwood logs, and is almost certain to be abundant in log houses of this wood. This belief was recently voiced by Capt. S. M. Swigert, U. S. A., who reports that it often occurs in numbers under the bark of dead trees of cottonwood (*Populus monilifera*), especially along the Big and Little Horn rivers in Montana.

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however, known to be able to survive for long periods without food, specimens having been kept for a year in a sealed vial, with absolutely no means of sustenance whatever, and in unoccupied houses it can undoubtedly undergo fasts of extreme length. Individuals obtained from eggs have been kept in small sealed vials in this office for several months, remaining active and sprightly in spite of the fact that they had never taken any nourishment whatever.

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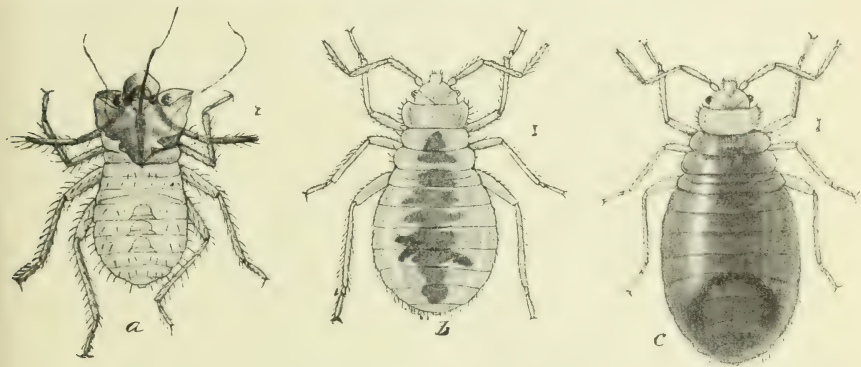


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only part ordinarily seen in examining the insect), within which lie four thread-like hard filaments or setæ which glide over each other with an alternating motion and pierce the flesh. The blood is drawn up through the beak, which is closely applied to the point of puncture, and the alternating motion of the setæ in the flesh causes the blood to flow more freely. The details of the structure of the beak are shown in Fig. 1, *d*. In common with other insects which attack men, it is entirely possible for these pests to be transmitters of contagious diseases.

Like its allies, the bedbug undergoes an incomplete metamorphosis, the young being very similar to their parents in appearance, structure and in habit. The eggs (fig. 2, *d*) are white oval objects, having a little projecting rim around one edge, and are laid in batches of from one-half dozen to fifty in cracks and crevices where the bugs go for concealment. The eggs hatch in a week or ten days, and the young escape by pushing the lid within the projecting rim from the shell. At first they are yellowish white, nearly transparent, the brown color of the more mature insect increasing with the later molts (fig. 3). During the course of development the skin is shed five times, and with the last molt the minute wing pads characteristic of the adult insect make their appearance. A period of about eleven weeks has been supposed to be necessary for the complete maturity of this insect, but we have found this period subject to great variation, depending on warmth and food supply. Breeding experiments conducted at this office indicate, under most favorable conditions, a period averaging eight days between moltings and between the laying of the eggs and their hatching, giving about seven weeks as the period from egg to adult insect. Some individuals under the same conditions will, however, remain two to three weeks between moltings, and without food, as already shown, they may remain unchanged for an indefinite time. Ordinarily but one meal is taken between molts, so that each bedbug must puncture its host five times before becoming mature and at least once afterwards before it again develops eggs. They are said to lay several batches of eggs during the season, and are extremely prolific, as occasionally realized by the housekeeper, to her chagrin and embarrassment.

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The bedbug, on account of its habits of concealment, is usually beyond the reach of powders, and the ordinary insect powders, such as pyrethrum, are of practically no avail against it. If iron or brass bedsteads are used the eradication of the insect is comparatively easy. With large wooden bedsteads, furnishing many cracks and crevices into which the bugs can force their flat, thin bodies, their extermination becomes a matter of considerable difficulty. The most practical way to effect this end is by very liberal applications of benzine or kerosene or any other of the petroleum oils. These must be introduced into all crevices with small brushes or feathers, or by injecting with small syringes. Corrosive sublimate is also of value, and oil of turpentine may be used in the same way. The liberal use of hot water, wherever it may be employed without danger to furniture, etc., is also an effectual method of destroying both eggs and active bugs. Various bedbug remedies and mixtures are for sale, most of them containing one or the other of the ingredients mentioned, and they are frequently of value. The great desideratum, however, in a case of this kind, is a daily inspection of beds and bedding and of all crevices and locations about the premises where these vermin may have gone for concealment. A vigorous campaign should, in the course of a week or so at the outside, result in the extermination of this very obnoxious and embarrassing pest.

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The fact that the bedbug has a very active enemy in the common house cockroach has already been alluded to, and the proof seems to be fairly conclusive. Another common insect visitor in houses, and a very annoying one also to the careful housekeeper, the little red ant (*Monomorium pharaonis*), is also known to be a very active and effective enemy of the bedbug. Mr. Theo. Pergande, of this office, informs me that during the late war, when he was with

the Union army, he occupied at one time barracks at Meridian, Miss., which had been abandoned some time before. The premises proved to be swarming with bedbugs; but very shortly afterwards the little red house ant discovered the presence of the bedbugs and came in in enormous numbers, and Mr. Pergande witnessed the very interesting and pleasing sight of the bedbugs being dismembered or carried away bodily by these very minute ants, many times smaller than the bugs which they were handling so successfully. The result was that in a single day the bedbug nuisance was completely abated. The liking of red ants for bedbugs is confirmed also by a correspondent writing from Florida (F. C. M. Boggess), who goes so far as to heartily recommend the artificial introduction of the ants to abate this bug nuisance. (Insect Life, Vol. VI, p. 340.) Bedbugs and other household insects, however, are not of the sort which it is convenient or profitable to turn over to their natural enemies in the hope that eradication by this means will follow, and the fact of their being preyed upon by other insects furnishes no excuse to the housekeeper for not instituting prompt remedial measures.

WASHINGTON, D. C., *June 15, 1902.*

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE BEDBUG.

(Cimex lectularius L.)

By C. L. MARLATT,

Entomologist and Acting Chief in Absence of Chief.

[Revised reprint from Bulletin No. 4, New Series, Division of Entomology, U. S. Department of Agriculture, pp. 32-38.]

The presence of the bedbug (fig. 1) in a house is not necessarily an indication of neglect or carelessness; for, little as the idea may be relished, this insect may often gain access in spite of the best of care and the adoption of all reasonable precautions. It is very apt to get

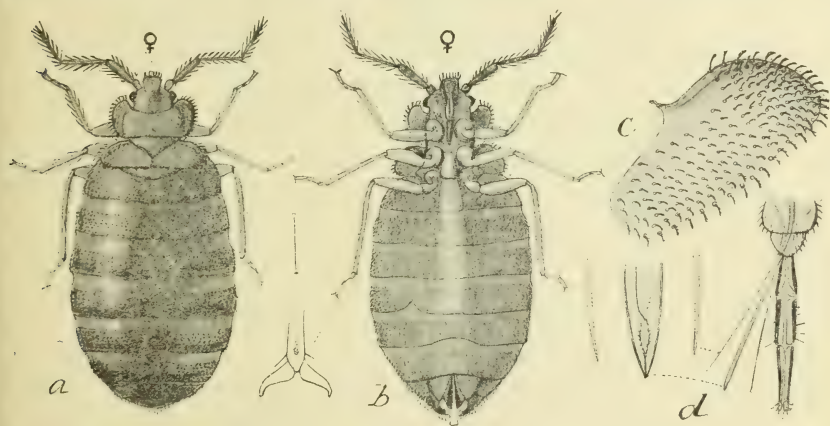


FIG. 1.—Bedbug (*Cimex lectularius*): a, adult female, gorged with blood; b, same from below; c, rudimentary wing pad; d, mouth parts. a, b. much enlarged; c, d, highly magnified (original).

into the trunks and satchels of travelers, and may thus be introduced into homes. Unfortunately, also, it is quite capable of migrating from one house to another and will often continue to come from an adjoining house, sometimes for a period of several months, gaining entrance daily. Such migration is especially apt to take place if the human inhabitants of an infested house leave it. With the failure of their usual source of food, the migratory instinct of the bedbugs is developed; and, escaping through windows, they pass along walls, water pipes, or gutters, and thus gain entrance into adjoining houses. In these or other ways it may be anyone's misfortune to have his premises temporarily invaded.

As with nearly all the insects associated with man, the bedbug has had the habits now characteristic of it as far back as the records run. It was undoubtedly of common occurrence in the dwellings of the ancient peoples of Asia. The Romans were well acquainted with it, giving it the name *Cimex*. It was supposed by Pliny (and this was doubtless the common belief among the Romans) to have medicinal properties, and it was recommended, among other things, as a specific for the bites of serpents. It is said to have been first introduced into England in 1503, but the references to it are of such a nature as to make it very probable that it had been there long before. Two hundred and fifty years later it was reported to be very abundant in the seaport towns, but was scarcely known inland.

One of the old English names was "wall-louse." It was afterwards very well known as the "chinch," which continued to be the common appellation for it until within a century or two and is still used in parts of this country. The origin of the name "bedbug" is not known, but it is such a descriptive one that it would seem to have been very naturally suggested. Almost everywhere there are local names for these parasites, as, for illustration, around Boston they are called "chintzes" and "chinchies," and from Baltimore comes the name "mahogany flat," while in New York they are styled "red coats."

The bedbug has accompanied man wherever he has gone. Vessels are almost sure to be infested with it. It is not especially limited by cold and is known to occur well north. It probably came to this country with the earliest colonists; at least Kalm, writing in 1748-49, stated that it was plentiful in the English colonies and in Canada, though unknown among the Indians.

The bedbug belongs to the order Hemiptera, which includes the true bugs or piercing insects, characterized by possessing a piercing and sucking beak. The bedbug is to man what the chinch bug is to grains or the squash bug to cucurbs. Like nearly all the insects parasitic on animals, however, it is degraded structurally, its parasitic nature and the slight necessity for extensive locomotion having resulted, after many ages, doubtless, in the loss of wings and the assumption of a comparatively simple structure. The wings are represented by the merest rudiments, barely recognizable pads, and the simple eyes or ocelli of most other true bugs are lacking. In form the bedbug is much flattened, obovate, and in color is rust red, with the abdomen more or less tinged with black. The absence of wings is a most fortunate circumstance, since otherwise there would be no safety from this pest, even for the most careful and thorough of housekeepers. Some slight variation in length of wing pads has been observed, but no individual with wings showing any considerable development has ever been found.

A closely allied species is a parasitic messmate in the nests of the common cliff or eaves swallow in this country, and it often happens that the nests of such birds are fairly alive with these vermin. The latter not infrequently gain access to houses and cause the housekeeper considerable alarm. At least three species occur also in England, all very closely resembling the bedbug. One of these is found in pigeon cotes, another in the nests of the English martin, and a third in places frequented by bats. What seems to be the true bedbug, or at best a mere variety, occurs occasionally in poultry houses.¹

The most characteristic feature of the insect is the very distinct and disagreeable odor which it exhales, an odor well known to all who have been familiar with it as the "buggy" odor. This odor is by no means limited to the bedbug, but is characteristic of most plant bugs also. The common chinch bug affecting small grains and the squash bugs all possess this odor, and it is quite as pungent with these plant-feeding forms as with the human parasite. The possession of this odor, dis-



FIG. 2.—Bedbug (*Cimex lectularius*): Egg and newly hatched larva: *a*, larva from below; *b*, larva from above; *c*, claw; *d*, egg; *e*, hair or spine of larva. Greatly enlarged, natural size of larva and egg indicated by hair lines (original).

agreeable as it is, is, after all, a most fortunate circumstance, as it is of considerable assistance in detecting the presence of these vermin. The odor comes from glands, situated in various parts of the body, which secrete a clear, oily, volatile liquid. With the plant-feeding forms this odor is certainly a means of protection against insectivorous birds, rendering these insects obnoxious or distasteful to their feathered enemies. With the bedbug, on the other hand, it is probably an illustration of a very common phenomenon among animals, i. e., the persistence of a characteristic which is no longer of any especial value to the possessor. The natural enemies of true bugs, against which this odor serves as a means of protection, in the conditions under which the bedbug lives, are kept away from it; and the roach, which sometimes feeds on bedbugs, is evidently not deterred by the odor, while the common

¹Insect Life, Vol. VI, p. 166, Osborn.

house ant, which will also attack the bedbug, seems not to find this odor disagreeable.

The bedbug is thoroughly nocturnal in habits and displays a certain degree of wariness and caution, or intelligence, in its efforts at concealment during the day. It thrives particularly in filthy apartments and in old houses which are full of cracks and crevices in which it can conceal itself beyond easy reach. It usually leaves the bed at the approach of daylight to go into concealment either in cracks in the bedstead, if the latter be one of the old wooden variety, or behind wainscoting or under loose wall paper, in these places manifesting its gregarious habit by collecting in masses. The old-fashioned heavy wooden bedsteads are especially favorable for the concealment and multiplication of this insect, and the general use in later years of iron and brass bedsteads has very greatly facilitated its eradication. Bedbugs are not apt to be very active in winter, especially in cold rooms, and ordinarily hibernate in their places of concealment.

The bedbug, though normally feeding on human blood, seems to be able to subsist, for a time at least, on much simpler food; and, in fact, the evidence is pretty conclusive that it is able to get more or less sustenance from the juices of moistened wood, or the moisture in the accumulations of dust, etc., in crevices in flooring. No other explanation would seem to account for the fact that houses long unoccupied are found, on being reinhabited, to be thoroughly stocked with bedbugs.

There is a very prevalent belief among the old settlers in the West that this insect normally lives on dead or diseased cottonwood logs and is almost certain to be abundant in log houses of this wood. This belief was recently voiced by Capt. S. M. Swigert, U. S. A., who reports that it often occurs in numbers under the bark of dead trees of cottonwood (*Populus monilifera*), especially along the Big and Little Horn rivers in Montana.

The origin of this misconception—for such it is, so far as the out-of-door occurrence is concerned—is probably, as pointed out by Professor Riley, from a confusion of the bedbug with the immature stages of an entirely distinct insect (*Aradus* sp.) which somewhat resembles the former and often occurs under cottonwood bark. In houses, green or moist cottonwood logs or lumber may actually furnish sustenance to the bedbug in the absence of its usual food. The bedbug is, however, known to be able to survive for long periods without food, specimens having been kept for a year in a sealed vial, with absolutely no means of sustenance whatever, and in unoccupied houses it can undoubtedly undergo fasts of extreme length. Individuals obtained from eggs have been kept in small sealed vials in this office for several months, remaining active and sprightly in spite of the fact that they had never taken any nourishment whatever.

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The sulphur or brimstone remedy has been used very successfully by Dr. C. W. Stiles, of the Bureau of Public Health and Marine-Hospital Service, for the disinfection of frame cottages, such as those at seaside resorts, where, from neglect, infestation with bedbugs may often occur. The treatment is inexpensive compared with the use of hydrocyanic-acid gas and offers much less risk of danger to human beings. Two pounds of sulphur are recommended for each thousand cubic feet of space, and the buildings should be closed for treatment at least twenty-four hours. Sulphur candles may be used where available. The precautions indicated in the quotation from Doctor Lintner should be observed.

The fact that the bedbug has a very active enemy in the common house cockroach has already been alluded to, and the proof seems to be fairly conclusive. Another common insect visitor in houses, and a very annoying one also to the careful housekeeper—the little red ant (*Monomorium pharaonis*)—is also known to be a very active and effective enemy of the bedbug. Mr. Theo. Pergande, of this office, informs me that during the civil war, when he was in the Union army, he occupied at one time barracks at Meridian, Miss., which had been

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Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *January 15, 1907.*

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United States Department of Agriculture,

DIVISION OF ENTOMOLOGY,

L. O. HOWARD, Entomologist.

THE HOUSE CENTIPEDE.

(Scutigera forceps Raf.)

By C. L. MARLATT,

First Assistant Entomologist.

[Reprint from Bulletin No. 4, New Series, Division of Entomology, U. S. Department of Agriculture, pp. 47-50.]

This centipede (fig. 1), particularly within the last ten or twelve years, has become altogether too common an object in dwelling houses in the Middle and Northern States for the peace of mind of the inmates. It is a very fragile creature, capable of very rapid movements, and elevated considerably above the surface upon which it runs by very numerous long legs. It may often be seen darting across floors with very great speed, occasionally stopping suddenly and remaining absolutely motionless, presently to resume its rapid movements, often darting directly at inmates of the house, particularly women, evidently with a desire to conceal itself beneath their dresses, and thus creating much consternation. The creature is not a true insect, but belongs to the Myriopoda, commonly known as centipedes or "thousand legs," and is sometimes called the "skein" centipede, from the fact that when crushed or motionless it looks, from its numerous long legs, like a mass of filaments or threads. It is a creature of the damp, and is particularly abundant in bathrooms, moist closets, and cellars, multiplying excessively also in conservatories, especially about places where pots are stored, and near heating pipes. In houses it will often be dislodged from behind furniture or be seen to run rapidly across the room, either in search of food or concealment. If examined closely its very cleanly habits may occasionally be manifested in that it may be observed to pass its long legs, one after another, through its mandibles, to remove

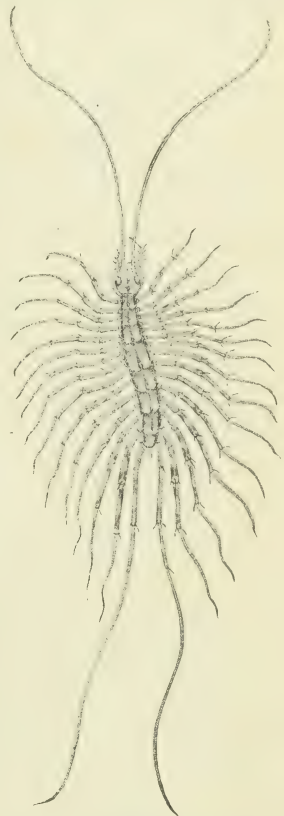


FIG. 1.—*Scutigera forceps*:
Adult—natural size (original).

any adhering dust. Its rather weird appearance, its peculiar manner of locomotion, and frequently its altogether too friendly way of approaching people, give it great interest, and, with its increasing abundance in the North, make it a subject of frequent inquiry. It is a Southern species, its normal habitat being in the southern tier of States and southwestward through Texas into Mexico. It has slowly spread northward, having been observed in Pennsylvania as early as 1849, and reaching New York and Massachusetts twenty or twenty-five years ago, but for many years after its first appearance in the latter States it was of rare occurrence. It is now very common throughout New York and the New England States, and extends westward well beyond the Mississippi, probably to the mountains.

It is a very delicate creature, and it is almost impossible to catch it, even should one desire to do so, without dismembering several of its numerous legs, or crushing it. If crushed under the foot, as one's first impulse would suggest, nothing remains but a mass of intertwined limbs, giving it the appearance of a tangle of threads. If captured, so that it can be more readily examined, it will be found to consist of a worm-like body of an inch or a little more in length, armed at the head with a pair of very long, slender antennæ, and along the sides with a fringe of fifteen pairs of long legs. The last pair are much longer than the others, in the female more than twice the length of the body. In color it is of a grayish yellow, marked above with three longitudinal dark stripes. Examination of its mouth parts shows that they are very powerful, and fitted for biting, indicating a predatory or carnivorous habit.

The indications of its mouth parts are borne out by its food habits, besides being indicated by the known food habits of the other members of the group of centipedes to which it belongs. It was inferred, before any direct observations were made, that its food was probably house flies, roaches, and any other insect inhabitants of dwellings. Later many direct observations have confirmed this inference, and in captivity, on the authority of Professor Hargitt, it feeds readily on roaches, house flies, and other insects. Miss Murtfeldt reports also having observed specimens devouring small moths. During the act of devouring a moth they kept their numerous long legs vibrating with incredible swiftness, so as to give the appearance of a hazy spot or space surrounding the fluttering moth (Insect Life, Vol. VI, p. 258). It is supposed also to feed on the bedbug, and doubtless will eat any insect which it captures, and its quickness and agility leave few insects safe from it.

Messrs. Fletcher and Howard observed its mode of capturing the croton bug, which is interesting as illustrating the habits of this centipede and its allies. In this instance the centipede sprang over

its prey, inclosing and caging it with its many legs. In its habit of springing after its prey this centipede is similar to spiders, which it also resembles in its rapacious habits. It would therefore seem to be a very efficient enemy of many of our house pests. The common idea that it probably feeds on household goods and woollens or other clothing has no basis in fact.

The popular belief is that this centipede is extremely poisonous, and, as it belongs with the poisonous group of centipedes, it can not be questioned but that the bite of the creature is probably somewhat poisonous as well as painful, though the seriousness of the results will be dependent, as in all similar cases, on the susceptibility of the patient. The poison injected in the act of biting is probably merely

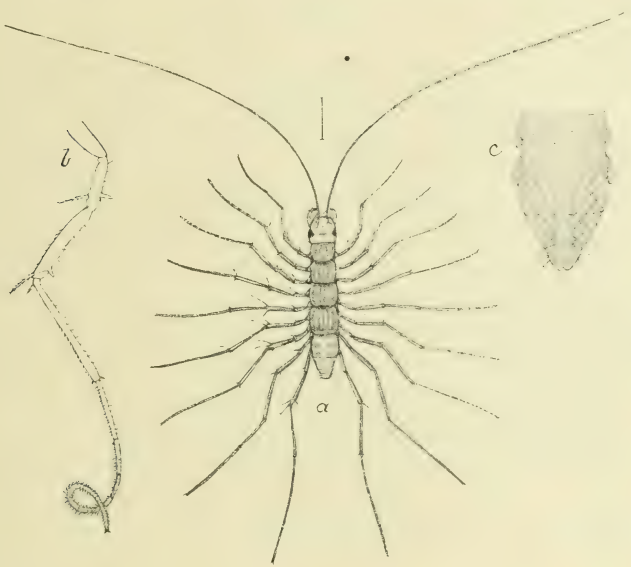


FIG. 2.—*Scutigera forceps*: a, newly-hatched individual; b, one of legs of same; c, terminal segment of body showing undeveloped legs coiled up within—all enlarged (original).

to assist in numbing and quieting its victim, and in spite of its abundance in houses in the North, and for many years its much greater abundance in the South, very few cases are recorded of its having bitten any human being, and it is very questionable whether it would ever, unprovoked, attack any large animal. If pressed with the bare foot or hand, or if caught between sheets in beds, this, like almost any other insect, will unquestionably bite in self-defense, and the few such cases on record indicate that severe swelling and pain may result from the poison injected. Prompt dressing of the wound with ammonia will greatly alleviate the disagreeable symptoms.

Little is known of the early life history of this Myriapod. It is found in the adult state in houses during practically the entire year. Half-grown individuals are also found frequently during the summer. A newly born specimen, found by Mr. H. G. Hubbard in the Department Insectary under a moist section of a log, differed from the older forms chiefly in possessing fewer legs. Its characteristics are indicated in fig. 2. A very interesting feature of this specimen is that the terminal segment of the body contains the long posterior legs folded up within it as indicated at fig. 2, c. They are doubtless liberated at the next moulting. In the half-grown and later stages this centipede does not differ materially from the adult, except in size, and its habits throughout life are probably subject to little variation.

REMEDIES.

If it were not for its uncanny appearance, which is hardly calculated to inspire confidence, especially when it is darting at one with great speed, and the rather poisonous nature of its bite, it would not necessarily be an unwelcome visitor in houses, but, on the contrary, might be looked upon rather as an aid in keeping in check various household pests. Its appearance in dwellings, however, will not often be welcome notwithstanding its useful rôle. It can be best controlled by promptly destroying all the individuals which make their appearance, and by keeping the moist places in houses free from any object behind which it can conceal itself, or at least subjecting such locations to frequent inspection. In places near water pipes, or in storerooms where it may secrete itself and occur in some numbers, a free use of fresh pyrethrum powder is to be advised.

WASHINGTON, D. C., *June 10, 1902.*

United States Department of Agriculture,

DIVISION OF ENTOMOLOGY,

L. O. HOWARD, Entomologist.

THE SILVER FISH.

(*Lepisma saccharina* Linn.)

By C. L. MARLATT,

First Assistant Entomologist.

[Revised reprint from Bulletin No. 4, New Series, Division of Entomology, U. S. Department of Agriculture, pp. 76-78.]

This insect (fig. 1) is often one of the most troublesome enemies of books, papers, card labels in museums, and starched clothing, and occasionally stored food substances. Its peculiar fish-like form and scaly, glistening body, together with its very rapid movements and active efforts at concealment whenever it is uncovered, have attached considerable popular interest to it and have resulted in its receiving a number of more or less descriptive popular names, such as silver fish, silver louse, silver witch, sugar fish, etc. The species named above is the common one in England, but also occurs in this country, and, like most other domestic insects, is now practically cosmopolitan. It has a number of near allies, which closely resemble it, both in appearance and habits. One of these (*Lepisma* (*Thermobia*) *domestica* Pack) has certain peculiarities of habit which will be referred to later. The peculiar appearance of the common silver fish early drew attention to it, and a fairly accurate description of it, given in a little work published in London in 1665 by the Royal Society, is interesting enough to reproduce:

It is a very small, silvery, shining worm or moth which I found much conversant among books and papers, and is supposed to be that which corrodes and eats holes through the leaves and covers. It appears to the naked eye a small, glittering, pearl-colored moth, which, upon the removing of books and papers in the summer, is often observed very nimbly to scud and pack away to some lurking cranny where it may better protect itself from any appearing dangers. Its head appears big and blunt, and its body tapers from it toward the tail, smaller and smaller, being shaped almost like a carret.¹



FIG. 1.—*Lepisma saccharina*: adult—enlarged (original).

¹ Micrographia, R. Hooke, London, 1665.

On account of its always shunning the light and its ability to run very rapidly to places of concealment, it is not often seen and is most difficult to capture, and being clothed with smooth, glistening scales, it will slip from between the fingers and is almost impossible to secure without crushing or damaging. It is one of the most serious pests in libraries, particularly to the binding of books, and will frequently eat off the gold lettering to get at the paste beneath, or, as reported by Mr. P. R. Uhler, of Baltimore, often gnaws off white slips glued on the backs of books. Heavily glazed paper seems very attractive

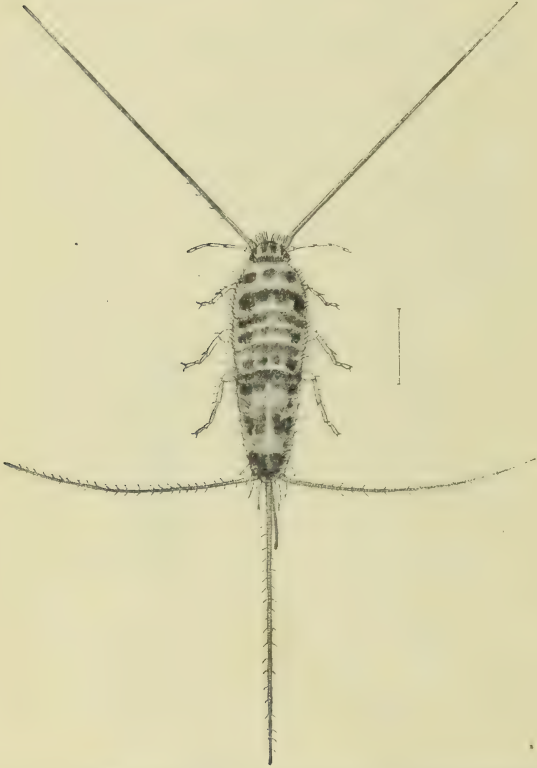


FIG. 2.—*Lepisma domestica*: adult female—enlarged (original).

to this insect, and it has frequently happened that the labels in museum collections have been disfigured or destroyed by it, the glazed surface having been entirely eaten off. In some cases books printed on heavily sized paper will have the surface of the leaves a good deal scraped, leaving only the portions covered by the ink. It will also eat any starched clothing, linen, or curtains, and has been known to do very serious damage to silks which had probably been stiffened with sizing. Its damage in houses, in addition to its injury to books,

consists in causing the wall paper to scale off by its feeding on the starch paste. It occasionally gets into vegetable drugs or similar material left undisturbed for long periods. It is reported also to eat occasionally into carpets and plush-covered furniture, but this is open to question.

The silver fish belongs to the lowest order of insects—the Thysanura—is wingless, and of very simple structure. It is a worm-like insect about one-third of an inch in length, tapering from near the head to the extremity of the body. The head carries two prominent antennæ, and at the tip of the body are three long, bristle-shaped

appendages, one pointing directly backward and the other two extending out at a considerable angle. The entire surface of the body is covered with very minute scales like those of a moth. Six legs spring from the thorax, and, while not very long, they are powerful and enable the insect to run with great rapidity.

In certain peculiarities of structure, and also in their habits, these anomalous insects much remind one of roaches, and their quick, gliding movements and flattened bodies greatly heighten this resemblance. More striking than all, however, is the remarkable development of the coxæ or basal joints of the legs in the silver fish, which finds its counterpart in roaches, and, taken in connection with the other features of resemblance, seems to point to a very close alliance between the two groups, if, indeed, the silver fish are not merely structurally degraded forms of roaches and to be properly classed with the Blattidæ.

Another of the common silver fishes of this country, referred to in the opening paragraph, has developed a novel habit of frequenting ovens and fireplaces, and seemingly revels in an amount of heat which would be fatal to most other insects. It disports itself in numbers about the openings of ranges and over the hot bricks and metal, manifesting a most surprising immunity from the effects of high temperature. This heat-loving or bake-house species (fig. 33) was described in 1873 as *Lepisma domestica* by Packard, who reported it to be common about fireplaces at Salem, Mass. This species is also very abundant in Washington. What is evidently this same insect has become very common, particularly in the last year or two, in England and on the Continent, where it manifests the same liking for hot places exhibited by it in this country. The habit of this species of congregating in bake-houses and dwellings, about fireplaces and ovens, has given rise to the common appellation for it in England of "fire-brat." Similar descriptive names are applied to it also on the Continent. This species closely resembles the common silver fish in size and general appearance, but may be readily distinguished from it by the presence on the upper surface of dusky markings. It also possesses well-marked structural differences, which have led to its late reference to a distinct genus—*Thermobia*. An Italian entomologist, Rovelli, has described this insect under the descriptive name *furnorum*, from its inhabiting ovens, and the name of the genus to which it is now assigned by English entomologists is also descriptive of its heat-loving character. A Dutch entomologist, Oudemans, reports that he has found it in abundance in all bakehouses that he has examined in Amsterdam, where it is well known to bakers and has received a number of familiar names.

REMEDIES.

Advantage may be taken of the liking of these insects for fabrics and other articles containing starch to poison them by slipping into all the crevices where they occur—in bookshelves and backs of mantels, under washboards, and in the bottoms of drawers—bits of cardboard on which a thick boiled starch paste liberally poisoned with arsenic has been spread and dried. One of our correspondents reports complete relief by this measure. The silver fish readily succumbs to pyrethrum, and wherever this can be applied, as on book shelves, it furnishes one of the best means of control. For starched clothing and similar objects liable to be injured by it, frequent handling and airing and the destruction by hand of all specimens discovered is to be recommended, in addition to the poisoned cardboard remedy. Little damage is liable to occur in houses except in comparatively moist situations or where stored objects remain undisturbed for a year or more.

WASHINGTON, *June 20, 1902.*



United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE WHITE ANT.

(*Termes flavipes* Koll.).

By C. L. MARLATT,

Entomologist and Acting Chief in Absence of Chief.

No insect occurring in houses is capable of doing greater damage than the one under consideration. Its injuries are often hidden until the damage is beyond repair, and as it affects the integrity of the building itself as well as its contents, the importance of the insect becomes very evident. Fortunately it is not often present in the North in houses,

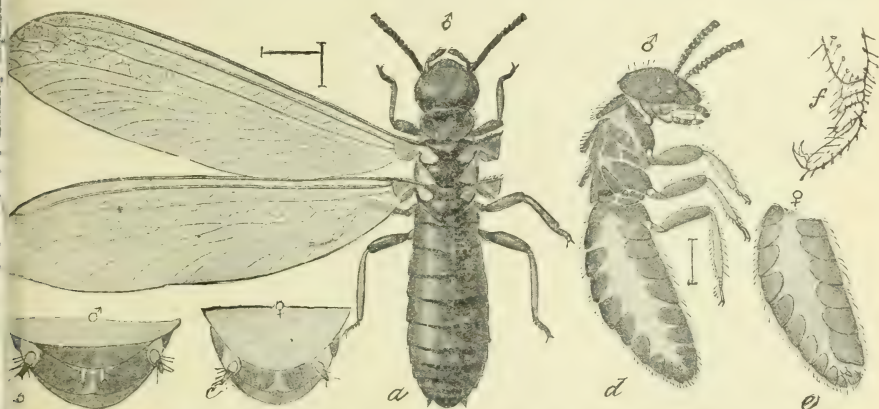


FIG. 1.—*Termes flavipes*: a, Adult male; b, terminal abdominal segments of same from below; c, same of female; d, male, side view, somewhat inflated by treatment with ammonia; e, abdomen of female, side view; f, tarsus, showing joints and claw; a, d, e, enlarged; b, c, f, greatly enlarged (original).

but as the Tropics are approached the injuries from it in dwellings or other structures of wood are of common experience and often of the most serious nature, causing the sudden crumbling of bridges and wharves and settling of floors or buildings.

The term "white ant," by which this insect is universally known, is entirely inappropriate in so far as it indicates any relationship with the true ants. Strictly speaking, the white ant is not an ant, but a neuropteroid insect belonging to the order Isoptera and is allied to the book lice and stone flies. The only analogy with ants is in superficial resemblance and in the social habits of the two groups, in which great similarity exists. The popular acquaintance with the termite or white ant is mainly derived from witnessing its nuptial spring flight, when the small brown, ant-like creatures with long glistening white wings emerge from cracks in the ground or from crevices in buildings, swarming out sometimes in enormous numbers, so that they may often be swept up

by the quart. These winged individuals are not the ones which do the damage, but are the colonizing form. The real depredators are soft-bodied, large-headed, milky white insects, less than a quarter of an inch in length, which may often be found in numbers under rotting boards or in decaying stumps. These last are the workers and soldiers (fig. 4, *c* and *d*), and constitute the bulk of the colony for most of the year, the winged migrating forms, consisting of the sexed individuals, appearing normally only once a year, usually in April or early in May.

The white ants present, in an entirely distinct order of insects, another of those most curious problems of communal societies which find so many examples among the ants, bees, and wasps. A colony of white ants includes workers, soldiers, the young of the various forms, and, at the proper season of the year, the winged males and females; also a single parent pair, the specially developed king and queen. In the case of the common white ant of this country (*Termes flavipes*), the fully developed queen or mother of the colony, swollen to great size by her enormous ovary development, and her consort, the fully developed but much smaller king or male, have never been found in the white ant communities, and this in spite of the great numbers of the flying stage of both sexes that appear every spring. The soldiers or workers are degraded or undeveloped individuals of both sexes, differing in this respect from ants and bees, in which the workers are all undeveloped females.

The economy of the termites is almost exactly analogous to that of the ants and bees. The workers attend to all the duties of the colony, make the excavations, build the nests, care for the young, and protect and minister to the wants of the queen or mother ant. In this they are assisted somewhat by the soldiers, whose duty, however, is also protective, their enormous development of head and jaws indicating their rôle as the fighters or defenders of the colony. Both the workers and soldiers are blind. The colonizing individuals differ from the others in being fully developed sexually and in the possession of very long wings, which normally lie flat over each other, the upper wings concealing the lower and both projecting beyond the abdomen. These wings have a very peculiar suture near the base, where they can be readily broken off, leaving mere stumps. At the time of the spring flight the winged individuals emerge from the colony very rapidly, frequently swarming in clouds out of doors, and after a short flight fall to the ground and very soon succeed in breaking off their long clumsy wings at the suture referred to. In this swarming or nuptial flight they come out in pairs, and under favorable conditions each pair might become especially developed, as described above, and establish a new colony, but in point of fact this probably rarely happens. They are weak flyers, clumsy, and not capable of extensive locomotion on foot, and are promptly preyed upon and destroyed by many insectivorous animals, so that rarely indeed do any of the individuals escape.

Theoretically, if one of these pairs succeeded in finding a decaying stump or other suitable location at hand, they would enter it, and the king and queen, being both active, would attend to the wants of the new colony and superintend the rearing of the first brood of workers and soldiers, which would then assume the laborious duties of the young colony. Thereafter the queen, being constantly and liberally fed and kept absolutely inactive, would increase immensely, her abdomen becoming many hundred times its original size. She would practically lose the power of locomotion and become a mere egg-laying machine of enormous capacity. Allied species whose habits have been studied in this particular indicate an egg-laying rate of 60 per minute, or something like 80,000 per day.

In the absence of a queen, however, white ants are able to develop from a very young larva or nymph of what would otherwise become a winged female what is known as a supplementary queen, which is never winged and never leaves the colony. This supplementary queen

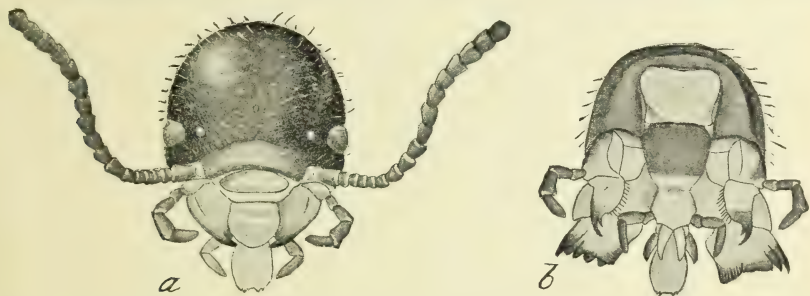


FIG. 2.—*Termes flavipes*: a, Head of winged female viewed from above; b, same from below, with mouth parts opened out. Greatly enlarged (original).

(fig. 4, a), for the discovery of which we are indebted to the late H. G. Hubbard, is smaller than the perfect sexed queen, but subserves all the needs of the colony in the matter of egg laying, and is the only parent insect so far found in the nests of the common white ant in this country. Whether a true queen exists or not is, therefore, open to question; if not, all the individuals which escape in the spring and summer migrations must perish, and this swarming would, therefore, have to be considered a mere survival of a once useful feature in the economy of this insect, now no longer, or rarely, of service.

The normal method of the formation of new colonies is probably by the mere division or splitting up of old ones—their galleries and branch colonies extending great distances from the home colony—or through the carrying of infested logs or timbers from one point to another.

These curious insects have a very simple development. There is scarcely any metamorphosis, the change from the young larva to the adult being very gradual and without any marked difference in structure. They feed on decaying wood or vegetable matter of any sort, and are able to carry their excavations into any timbers which are

moistened, or into furniture, books, or papers stored in rooms which are at all moist. Their food is the finely divided material into which they bore, and from which they seem able to extract a certain amount of nourishment, probably from the molds and ferments generated in the moistened vegetable substance, since they redevour the same material several times. Bearing out this theory, tropical species are known to grow mushroom beds artificially on the product of which they largely subsist. The white ants are also somewhat cannibalistic, and will devour the superfluous members of the colony without compunction, and they normally consume all dead individuals, cast skins, and other refuse material. They are capable also of exuding a sort of nectar, which is used to feed the young and the royal pair, and which they also generously give to one another.

All except the migrating winged forms are incapable of enduring full sunlight, and the soft, delicate bodies of the workers, soldiers, and young rapidly shrivel when exposed. In all their operations, therefore, they carefully conceal themselves, and in their mining of timbers or books and papers the surface is always left intact; whenever it is necessary for them to extend their colonies it is done only under the protection of covered runways, which they construct of particles of comminuted wood or little pellets of excrement. In this way the damage which they are doing is often entirely hidden, and not until furniture breaks down or the underpinning and timbers of houses or floors yield is the injury recognized. The swarming of winged individuals in the early summer, if in or about houses, is an indication of their injurious presence and warrants an immediate investigation to prevent serious damage later on.

The common termite of America is very widespread, occurring from the Atlantic to the Pacific and from Canada southward to the Gulf. It has been found on the mountains of Colorado and Washington at a height of over 7,000 feet. In prairie regions it may often be seen during the swarming season issuing from the ground at frequent intervals over large pasture tracts, where it must feed on the roots of grass and other herbage. It has also been carried to other countries and is a common and often very injurious enemy of buildings and libraries in Europe. A closely allied and equally injurious European species (*Termes lucifugus*) has also been brought to this country in exchange for ours, but compared with our own species it is somewhat rare though already widely distributed. In this country serious damage to buildings from the white ant has not been of common occurrence, especially in the North, except in some notable instances. In Europe our species has caused greater damage, and some years ago gained access to one of the Imperial hothouses at Vienna, and in spite of all efforts to save the building it was necessary ultimately to tear it down and replace it with an iron structure. In this country instances are on record of very serious damage to books and papers. An accumulation of books and

papers belonging to the State of Illinois was thoroughly ruined by their attacks. A school library in South Carolina, which had been left closed for the summer, was found on being opened in the autumn to be completely eaten out and rendered valueless. In the Department of Agriculture an accumulation of records and documents stored in a vault not perfectly dry, and allowed to remain undisturbed for several years, on examination proved to be thoroughly mined and ruined by white ants. Humboldt, on the authority of Hagen, accounts for the rarity of old books in New Spain by the frequency of the destructive work of these insects.

Numerous instances of damage to underpinning of buildings and to timbers are also on record. The flooring of one of the largest sections of the United States National Museum was for some years annually undermined and weakened by a very large colony of these pests which could not be located, and finally the authorities solved the problem by replacing the wood floor with one of cement. A few years ago it was found necessary to tear down and rebuild three frame buildings in Washington in consequence of the work of this insidious foe, and renewal of foundation timbers or replacing with artificial stone is often called for.

Damage of the sort mentioned has occurred as far north as Boston, but, as stated, greatly increases as one approaches the Tropics, where the warmth and moisture are especially suited to the development and multiplication of this insect. There houses and furniture are never safe from attack. The sudden crumbling into masses of dust of chairs, desks, or other furniture, and the mining and destruction of collections of books and papers, are matters of common experience, very little hint of the damage being given by a surface inspection, even when the interior of timbers or boards has been thoroughly eaten out, leaving a mere shell.

While confining their work almost solely to moistened or decaying timbers or vegetable material of any sort, and books and papers that are somewhat moist, termites are known to work also in living trees, carrying their mines through the moist and nearly dead heartwood. In this way some valuable trees in Boston were so injured as to make their removal necessary. In Florida these insects have been the cause of considerable damage to newly planted groves of orange trees, working around the crowns and in the roots. The damage has been chiefly noted in recent clearings where a good deal of rotten wood still remained in the soil, this accounting for their presence. These insects are some-

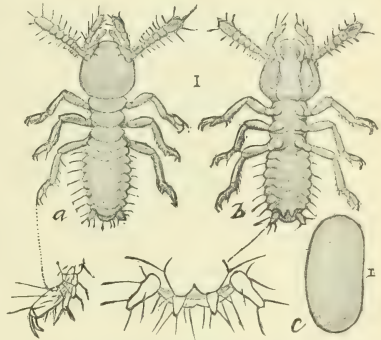


FIG. 3.—*Termes flavipes*: a, Newly hatched larva; b, same from below; c, egg. All enlarged (original).

times also the occasion of considerable injury to other trees; and quite recently the writer received information of injurious attacks on pecan, chestnut, and walnut trees at Augusta, Ga. They also cause loss in conservatories, attacking cuttings and the roots of plants. Such injuries have been brought to our notice several times by florists, and Mr. Chittenden, of this office, informs me that white ants are apt to attack the large stems of herbaceous plants like geraniums. In greenhouses the termites usually originate in the more or less decayed woodwork of the building itself or the plant benches, and they have even been found

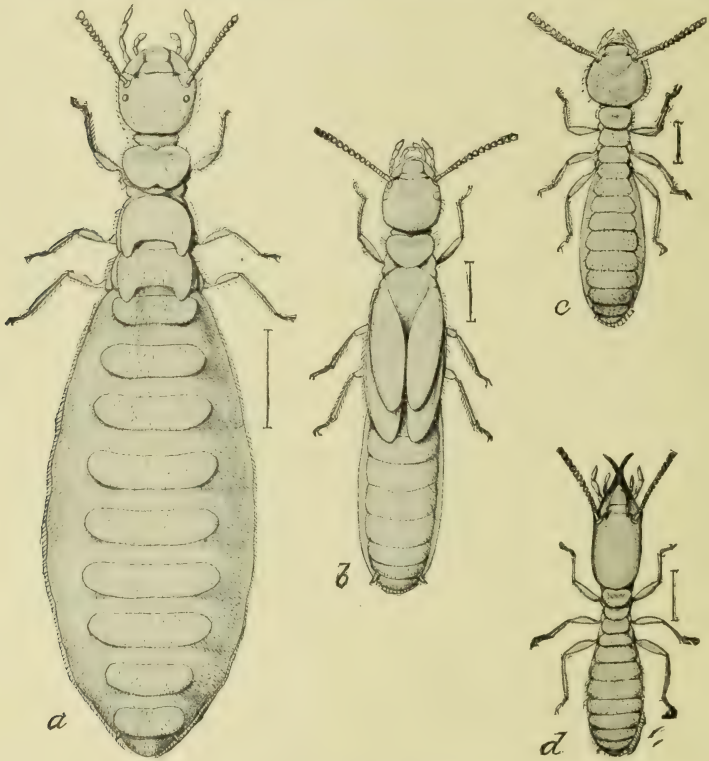


FIG. 4.—*Termes flavipes*: a, Queen; b, nymph of winged female; c, worker; d, soldier. All enlarged (original).

working in label sticks, the removal of which gave relief from the damage done to plants. In one instance, also, the termites, coming from the wooden benches, entered potted plants through the drain hole of the pots. In prairie regions their work is necessarily on the roots and tubers of plants or the stems of grasses or other low-growing plants.

A very common form of injury to potatoes growing in rich soil or where there is a considerable quantity of decaying vegetable matter has often been noted, and the cause for it has been obscure or assigned to insects innocent of the damage. That the white ant is the culprit in this case was discovered by Mr. F. A. Marlatt, who describes the injury

to the tubers as having the form of scars or pits covering the surface, the pits varying in shape from irregular holes to long, irregular excavations sometimes extending far into the potato, but commonly to a depth of from an eighth to a fourth of an inch. In all cases these pits are more or less overhung and covered by the dead and dying skin, and are also lined with the cellular tissue of potato, showing that the insect cares most for the starch and water of the tuber. Such damage may occur not only in soil rich in vegetable matter but also in newly cleared soil or soil containing the loose and decayed portions of trees, and in the instance cited above was in soil from which an old apple orchard had recently been cleared.

PREVENTIVES.

White ant infestation of houses is probably always from an outside source. The queen chamber and breeding center of the colony may be and usually is remote from the building, but the workers construct minute galleries or tunnels through the ground and go long distances in search of moist and decaying wood. Their entrance to buildings is gained through some of these soil channels by way of wooden beams or joists sunk in concrete in the foundations of the buildings, or the supports of porches or other parts of the edifice which come in contact with the soil. The fact that the beams or joists of the basement are entirely inclosed or imbedded in concrete is only a partial protection. In the settling of the house concrete is almost sure to crack, allowing avenues of ingress, and the beams and joists put down in the moist material soon partially decay and become exceptionally good breeding places; from such beams the white ants carry their burrows up through the timbers to the first and even second floors. To be on the safe side, therefore, the foundations of buildings should be entirely of brick, stone, or concrete, including the basement floor, and especially should this method of construction be followed in tropical and subtropical regions.

In the case of old buildings not constructed in this way considerable protection can be gained by surrounding them with clear spaces and graveled or asphalted walks, and looking after the prompt removal of any decaying stumps or partially rotted posts that may be in adjacent grounds. Complete dryness is an important means of rendering buildings safe from attack. Books and valuable documents should not be packed away in unventilated chambers where they may become moist and moldy, and are then particularly subject to attack by white ants, which are very likely to be present in old buildings even though their work has not been sufficient to bring them into special notice.

Impregnation with creosote renders wood comparatively immune from the attacks of white ants, and in regions where injury is to be anticipated it would be well to use wood so treated wherever it comes in contact with the ground. A heavy coating of foundation timbers with tar is often resorted to, and this protects the wood as long as the

coating is intact. Certain woods, also, are fairly immune, and of these the redwood of California is most accessible and seems to have a good record. Capt. Geo. P. Ahearn, U. S. Army, reports that California redwood has been used for more than twenty-five years in the Philippines, and has never been known to be injured by white ants. Its use in Manila is very general, especially for the construction of cabinets, filing cases, etc., where it is desirable to protect valuable papers from these insects.

In the Tropics household furniture, such as stands and bureaus, not in daily use can be protected by placing the legs in small vessels containing oil. Furniture, furthermore, should not lean against or touch walls, especially in houses of wood, and frequent examinations should be made of libraries and of stored papers.

REMEDIES.

The presence of flying termites in a building at any time in the spring or summer should be followed immediately by a prompt investigation to determine the extent of the infestation and the possibilities of further damage. The point of emergence of winged individuals may approximately, though not always, indicate the location of the infested timbers, and if these can be replaced injury may be checked, or, under favorable circumstances, stopped. In some cases thorough and repeated drenching of infested timbers, where accessible, with kerosene or some other petroleum oil will afford relief, but probably will not stop entirely the work of the termites, which, as indicated under the heading of "Preventives," are constantly recruited from some central colony probably distant from the building. The destruction of winged individuals as they emerge is of no value whatever. Where the injury is confined to books and papers or exposed woodwork and furniture, hydrocyanic-acid gas fumigation is to be recommended, exposing if possible also, by opening up floors, the infested joists beneath, and spreading out the books and opening cases and wardrobes. For description of the use of hydrocyanic-acid gas see Circular No. 46 of this series. It is very rarely possible to find and destroy the external colony, and if the remedies noted are not feasible or prove ineffective there is no other course but to replace the foundation of the buildings with walls and floorings of stone, concrete, or other form of rock composition. In the case of the National Museum building in Washington and several private edifices this course was finally adopted, with the result that white ants were completely excluded and their work terminated.

Approved :

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *December 30, 1907.*

United States Department of Agriculture,
BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

COCKROACHES.

By C. L. MARLATT,

Entomologist and Assistant Chief of Bureau.

[Revised reprint from Bulletin No. 4, New Series, Division of Entomology, U. S. Department of Agriculture, pp. 84-95.]

Roaches are among the commonest and most offensive of the insects which frequent human habitations. They were well known to the ancients, who called them *lucifuga*, from their habit of always shunning the light. The common English name for them, or, more prop-

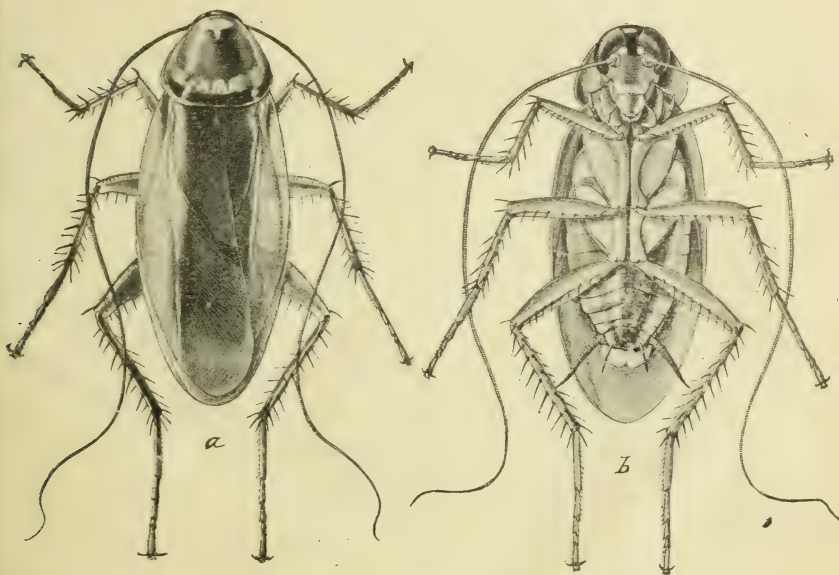


FIG. 1.—The American roach (*Periplaneta americana*): a, View from above; b, from beneath. Both enlarged one-third (original).

erly, for the common domestic English species, is "black beetle." In America this name has not been adopted to any extent for this insect, which was early introduced here, and the term "roach," or "cockroach," is the common appellation of all the domestic species. The little German roach, however, is very generally known as the Croton

bug, or water bug, from its early association with the Croton water-works system in New York City. The popular designations of this insect in Germany illustrate in an amusing way both sectional and racial prejudices. In north Germany these roaches are known as "Schwabens," a term which applies to the inhabitants of south Germany, and the latter section retaliates by calling them "Preussen," after the north Germans. In east Germany they are called "Russen," and in west Germany "Franzosen," the two latter appellations indicating a certain national antipathy to rival countries as well as a fanciful idea as to origin. Still other names are "Spanier," dating from the time of Charles V, and "Däne," from Denmark.

DISTRIBUTION AND HISTORY.

The roaches belong to a very extensive family, the Blattidæ, comparatively few of which, fortunately, have become domesticated. In temperate countries some four or five species are very common household pests, and a few occur wild in the woods; but they are essentially inhabitants of warm countries, and in the Tropics the house species are very numerous, and the wild species occur in great number and variety, many of them being striking in shape, coloration, and size, one species expanding more than 6 inches. The inability of the domestic roaches to withstand unusual cold was illustrated by the fact that the severe weather in the winter of 1894 in Florida, which was so destructive to the citrus groves, on the authority of Mr. H. G. Hubbard destroyed all the roaches, even those in houses, except a few unusually well protected. Under suitable conditions in the more northern latitudes the domestic species often multiply prodigiously, and even in the far north a species occurs in the huts of the Laplanders, and sometimes entirely devours the stores of dried fish put away for winter consumption.

While the domestic species are few in number, nearly 300 species of Blattidæ have been described and preserved in museums, and it is estimated that perhaps upward of 5,000 species exist at the present time in different parts of the world. The great majority of the roaches live outdoors, and in warm countries have the reputation of living on plants and sometimes being very injurious. This belief has been recently questioned by Mr. J. G. O. Tepper, of South Australia, who states that in his experience these insects are eminently carnivorous, feeding on caterpillars and other soft-bodied insects, and that with the increase of certain species in his gardens, notably *Epilampra notabilis*, "the herbivorous larvæ disappear rapidly." Mr. Tepper points out that the injury to plants occasionally noted where roaches are abundant may very possibly be due to other insects or to snails which again have attracted the roaches and on which the latter feed. That

roaches will eat fruits and the starchy tubers and other products of plants is a common observation, but that they ever subsist on the green foliage of plants may be open to doubt.

The roach is one of the most primitive and ancient insects, in the sense of its early appearance on the globe, fossil remains of roaches occurring in abundance in the early coal formations, ages before the more common forms of insect life of the present day had begun to appear. The species now existing are few in number in comparison with the abundance of forms in the Carboniferous age, which might with propriety be called the age of cockroaches, the moisture and warmth of that distant period being alike favorable to plant growth and to the multiplication of this family of insects.

The house roaches of to-day were undoubtedly very early associated with man in his primitive dwellings, and through the agency of commerce have followed him wherever navigation has extended. In fact, on shipboard they are always especially numerous and troublesome, the moisture and heat of the vessels being particularly favorable to their development. It is supposed that the common Oriental cockroach, or so-called "black-beetle," of Europe (*Blatta orientalis* L.), is of Asiatic origin, and it is thought to have been introduced into Europe in the last two or three hundred years. The original home of this and the other common European species (*Blattella germanica* L.) is, however, obscure, and in point of fact they have probably both been associated with man from the earliest times, and naturally would come into the newly settled portions of Europe from the older civilizations of Asia and Egypt.

Of the other two domestic species especially considered in this paper, the Australian roach (*Periplaneta australasiae* Fab.), as its name implies, is a native of Australia, and the American roach (*P. americana* L.), of subtropical and tropical America.

Rarely do two of the domestic species occur in any numbers together in the same house. Often also of two neighboring districts one may be infested with one species, while in the other a distinct species is the commoner one. The different species are thus seemingly somewhat antagonistic, and it is even supposed that they may prey upon one another, the less numerous species being often driven out.

STRUCTURAL CHARACTERISTICS.

Although among the oldest insects geologically, roaches have not departed notably from the early types, and form one of the most persistent groups among insects. The house species are rather uniformly dark brown or dark colored, a coloration which corresponds with their habit of concealment during daylight. They are smooth and slippery insects, and in shape broad and flattened. The head is inflexed under

the body, so that the mouth parts are directed backward and the eyes directed downward, conforming with their groveling habits. The antennæ are very long and slender, often having upward of 100 joints. The males usually have two pairs of wings, the outer ones somewhat coriaceous and the inner ones more membranous and once folded longitudinally. In some species, as, for instance, the black beetle, the females are nearly wingless. The legs are long and powerful and armed with numerous strong bristles or spines. The mouth parts are well developed and have strong biting jaws, enabling these insects to eat all sorts of substances.

HABITS.

In houses roaches are particularly abundant in pantries and kitchens, especially in the neighborhood of fireplaces, on account of the heat. For the same reason they are often abundant in the oven rooms of bakeries or wherever the temperature is maintained above the normal. They conceal themselves during the day behind baseboards, furniture, or whatever security and partial protection from the light are afforded. Their very flat, thin bodies enable them to squeeze themselves into small cracks or spaces where their presence would not be suspected and where they are out of the reach of enemies. Unless routed out by the moving of furniture or disturbed in their hiding places, they are rarely seen, and if so discovered, make off with wonderful celerity, with a scurrying, nervous gait, and usually are able to elude all efforts at their capture or destruction. It may often happen that their presence, at least in the abundance in which they occur, is hardly realized by the housekeeper, unless they are surprised in their midnight feasts. Coming into a kitchen or pantry suddenly, a sound of the rustling of numerous objects will come to the ear, and if a light be introduced, often the floor or shelves will be seen covered with scurrying roaches hastening to places of concealment. In districts where the large American roach occurs they sometimes swarm in this way at night in such numbers that upon entering a small room in which they are congregated one will be repeatedly struck and scratched on the face and hands by the insects in their frantic flight to gain concealment.

The black roach is less active and wary than the others, and particularly the German roach, which is especially agile and shy.

The domestic roaches are practically omnivorous, feeding on almost any dead animal matter, cereal products, and food materials of all sorts. They are also said to eat their own cast skins and egg cases and it is supposed that they will attack other species of roaches, or at perhaps, occasionally cannibalistic. They will also eat or gnaw woods, leather (as of shoes or furniture), and frequently are the cause of extensive damage to the cloth and leather bindings of books in libraries and publishing houses. The sizing or paste used on the cloth covers

and in the binding of books is to them very attractive. The surface of the covers of cloth-bound books is often much scraped and disfigured, particularly by the German cockroach (*Blattella germanica*), and the gold lettering is sometimes eaten off to get at the albumen paste. On shipboard the damage is often very extensive, on account of the vast numbers of cockroaches which frequently occur there, and we have reliable accounts of entire supplies of ship biscuits having been eaten up or ruined by roaches.

The damage they do is not only in the products actually consumed, but in the soiling and rendering nauseous of everything with which they come in contact. They leave, wherever they occur in any numbers, a fetid, nauseous odor, well known as the "roachy" odor, which is persistent and can not be removed from shelves and dishes without washing with soap and boiling water. Food supplies so tainted are beyond redemption. This odor comes partly from the excrement, but chiefly from a dark-colored fluid exuded from the mouth of the insect, with which it stains its runways; and also in part, doubtless, from the scent glands, which occur on the bodies of both sexes between certain segments of the abdomen, and which secrete an oily liquid possessing a very characteristic and disagreeable odor. It frequently happens that shelves on which dishes are placed become impregnated with this roachy odor, and this is imparted to and retained by dishes to such an extent that everything served in them, particularly liquids, as coffee or tea, will be noticed to have a peculiar, disgusting, foreign taste and odor, the source of which may be a puzzle, and will naturally be supposed to come from the food rather than from the dish.

The roaches are normally scavengers in habit and may at times be of actual service in this direction by eating up and removing any dead animal material.

One other redeeming trait has been recorded of them, namely, that they will prey upon that other grievous pest of houses which are not subjected to careful supervision, the bedbug. Their habits in this direction have been recorded several times. One writer, in a narrative of a voyage (Foster's Voyage, Vol. I, p. 373), makes the following statement in this connection:

Cockroaches, those nuisances to ships, are plentiful at St. Helena, and yet, bad as they are, they are more endurable than bugs. Previous to our arrival here in the *Chanticleer*, we had suffered great inconvenience from the latter, but the cockroaches no sooner made their appearance than the bugs entirely disappeared. The fact is that the cockroach preys upon them and leaves no sign or vestige of where they have been. So that it is a most valuable insect.¹

The cockroach is, however, far too much of a nuisance itself to war-

¹ Proc. Ent. Soc. Lond., 1865, N. S. 3, p. 77.

rant its being recommended as a means of eradicating even the much more disagreeable insect referred to.¹

The local spread of roaches from house to house is undoubtedly often effected by their introduction with supplies, furniture, goods, etc. That the Croton bug, or German roach, and probably the other species also, may develop a migratory instinct has been witnessed by Doctor Howard and the writer in Washington. (See *Insect Life*, Vol. VII, p. 349.)

This very interesting instance of what seems to have been a true migration, in which an army of thousands of roaches by one common impulse abandoned their old quarters and started on a search for a more favorable location, illustrates, as pointed out by Doctor Howard, what is probably of frequent occurrence under the cover of darkness, and accounts for the way in which new houses frequently become suddenly overrun with these vermin.

TRANSFORMATION.

The roach in its different stages from egg to adult shows comparatively little variation in appearance or habits. The young are very much like the adults, except in point of size and in lacking wings, if the latter be winged in the adult state. In their mode of oviposition they present, however, a very anomalous and peculiar habit. The eggs, instead of being deposited separately, as with most other insects, are brought together within the abdomen of the mother into a hard, horny pod or capsule which often nearly fills the body of the parent. This capsule contains a considerable number of eggs, the number varying in the different species, arranged in two rows, the position of the eggs being indicated on the exterior of the capsule by transverse lateral impressions. When fully formed and charged with eggs the capsule is often partly extruded from the female abdomen and retained in this position sometimes for weeks, or until the young

¹ The following interesting letter from Mr. Herbert H. Smith, the collector and naturalist, gives a vivid picture of the roach nuisance in the Tropics:

Cockroaches are so common in Brazilian country houses that nobody pays any attention to them. They have an unpleasant way of getting into provision boxes, and they deface books, shoes, and sometimes clothing. Where wall paper is used they soon eat it off in unsightly patches, no doubt seeking the paste beneath. But at Corumba, on the upper Paraguay, I came across the cockroach in a new rôle. In the house where we were staying there were nearly a dozen children, and every one of them had their eyelashes more or less eaten off by cockroaches—a large brown species, one of the commonest kind throughout Brazil. The eyelashes were bitten off irregularly, in some cases quite close to the lid. Like most Brazilians, these children had very long, black eyelashes, and their appearance thus defaced was odd enough. The trouble was confined to children, I suppose because they are heavy sleepers and do not disturb the insects at work. My wife and I sometimes brushed cockroaches from our faces at night, but thought nothing more of the matter. The roaches also bite off bits of the toe nails. Brazilians very properly encourage the large house spiders, because they tend to rid the house of other insect pests.

larvæ are ready to emerge. The capsule is oval, elongate, or somewhat bean shaped, and one of its edges is usually serrate. The young are in some instances assisted to escape by the parent, who with her feet aids in splitting the capsule on the serrate edge to facilitate their exit. On hatching, it is said the young are often kept together by the parent and brooded over and cared for, and at least a colony of young will usually be found associated with one or two older individuals. These insects are more or less gregarious, notably so in the case of the black beetle of Europe and to a less extent with the German and American roaches.

They pass through a variable number of molts, sometimes as many as seven, the skin splitting along the back and the insects coming out white, soft, but rapidly hardening and assuming the normal color. Some astounding statements have been made as to the length of time required for the development of the roach from the egg to the adult. Four or five years have been said to be necessary for an individual to reach full growth; but more recent breeding experiments have not altogether confirmed these statements. Their development, however, is unquestionably slow, and probably under the most favorable conditions rarely is more than one generation per year produced. In colder countries the breeding and growth are practically restricted to the warm season. During the winter months they go into concealment and partial hibernation. *Blattella germanica* has been shown to reach full growth in a variable period of from four and a half to six months (Hummel, *Essais Entomologiques*, No. 1, St. Petersburg, 1821). The common American roach (*Periplaneta americana*) has been carried from the egg to the adult state in our insectary. Young hatching July 11 from an egg case received from Eagle Pass, Tex., reached the adult stage between March 14 and June 12 of the following year, indicating a period of nearly twelve months for complete development. The rate of growth of the roach undoubtedly depends very largely on food and temperature, and under unfavorable conditions the time required for development may undoubtedly be vastly lengthened. The abundance of roaches is, therefore, apparently not accounted for so much by their rapidity of multiplication as by their unusual ability to preserve themselves from ordinary means of destruction and by the scarcity of natural enemies.

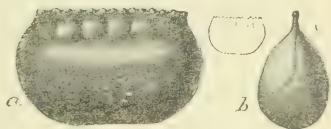


FIG. 2.—Egg capsule of *Periplaneta americana*: a, Side; b, end view. Natural size indicated by outline figure (original)

THE COMMON DOMESTIC ROACHES.

The four roaches which have been made the subject of illustrations represent the species which occur most commonly in houses, bakeries,

or on shipboard. The numerous tropical house species, many of which are perhaps only partially domesticated, and the subarctic roach of high altitudes and of the extreme north have been omitted.

The American roach (*Periplaneta americana*) (fig. 1) is the native or indigenous species of this continent, originating, it is supposed, in tropical or subtropical America.

The ancient and rather quaint account of this insect¹ quoted below in a footnote indicates that this species early came to the notice of our forefathers. Its domesticity doubtless resulted from ages of association with the aborigines. It has now become thoroughly cosmopolitan, and is unquestionably the most injurious and annoying of the species occurring on vessels. It is sometimes numerous also in greenhouses, causing considerable injury to tender plants. It is a notorious house pest and occasionally vies with the German roach in its injuries to book bindings. One of the most serious cases of injury of this sort was reported by the Treasury Department. The backs, sometimes entirely, of both cloth and leather-bound books were eaten off to get at the starchy paste used in the binding. (Insect Life, Vol. 1, pp. 67-70.)

This roach is very abundant in the Middle and Western States, where until recently it has been practically the only troublesome house species. In the East it is not often so common as are one or other of the following species and especially *germanica*. In foreign countries it has not become widespread and is largely confined to seaport towns. In size it is larger than any of the other domestic species, and it is light brown in color, the wings being usually long, powerful, and well developed in both sexes.

The Australian roach (*Periplaneta australasiae*) resembles very closely the last species, but differs strikingly in the brighter and more definitely limited yellow band on the prothorax and in the yellow dash on the sides of the upper wings (see fig. 3). In the United States it is the most abundant and troublesome species in Florida and some of the other Southern States. It is already practically cosmopolitan.

The Oriental cockroach, or black beetle (*Blatta orientalis*), is the common European and particularly the English species, and is notable for the fact that the female is nearly wingless in the adult

¹ *The cockroach*.—These are very troublesome and destructive vermin, and are so numerous and voracious that it is impossible to keep Victuals of any kind from being devoured by them without close covering. They are flat, and so thin that few chests or boxes can exclude them. They eat not only leather, parchment, and woollen, but linen and paper. They disappear in Winter and appear most numerous in the hottest days in Summer. It is at night they commit their depredations, and bite people in their beds, especially children's fingers that are greasy. They lay innumerable eggs, creeping into the holes of old walls and rubbish, where they lie torpid all the Winter. Some have wings and others are without—perhaps of different Sexes. (Catesby: Nat. Hist. Carolina, 1748, Vol. II, p. 10.)

state. The wings of the male also are shortened, not reaching to the extremity of the body. In color it is very dark brown, almost black, shining, and rather robust, much stouter than the other species, making its English name of "black beetle" quite appropriate. This species is notably gregarious in habit, individuals living together in colonies in the most amicable way, the small ones being allowed by the larger ones to sit on them, run over them, and nestle beneath them without any resentment being shown. This species was a common and troublesome pest in the British Colonies early in the eighteenth century,

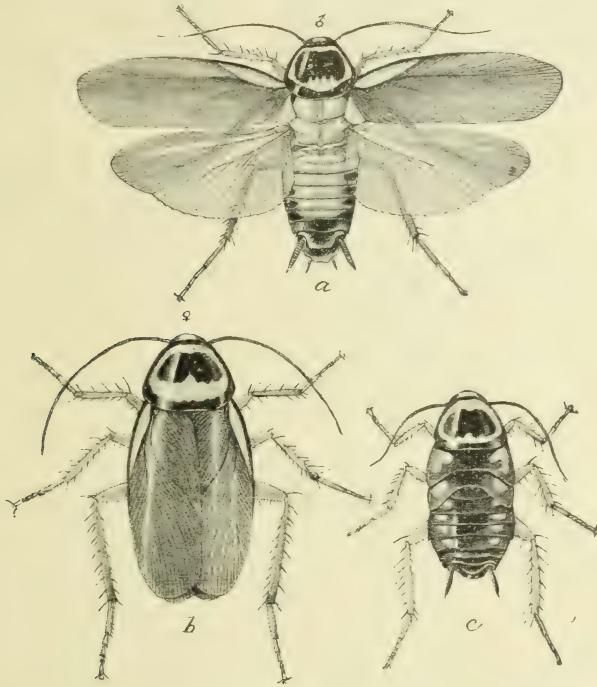


FIG. 3.—The Australian roach (*Periplaneta australasiae*): a, Male with spread wings; b, female; c, pupa. All life-size (original).

although unknown at the same time in the French Canadian possessions.¹

It then seemed to be commonly known as the mill beetle. The early Dutch called them *Kakerlach*, and in the Swede settlements they were known as *Brodetare* (bread eaters). It is now very common in houses in the East, but is quite generally distributed, and is the common species even so far removed from the Atlantic seaboard as New Mexico. The characteristics of this insect are shown in the accompanying illustration (fig. 4).

The German cockroach (*Blattella germanica*) is particularly abundant in Germany and neighboring European countries, but, like most

¹ See Kalm's Travels, Vol. I, p. 321; II, p. 256.

of the other domestic species, has become world-wide in distribution. In this country it is very often styled the Croton bug, this designation coming from the fact, already alluded to, that attention was first permanently drawn to it at the time of the completion of the Croton system

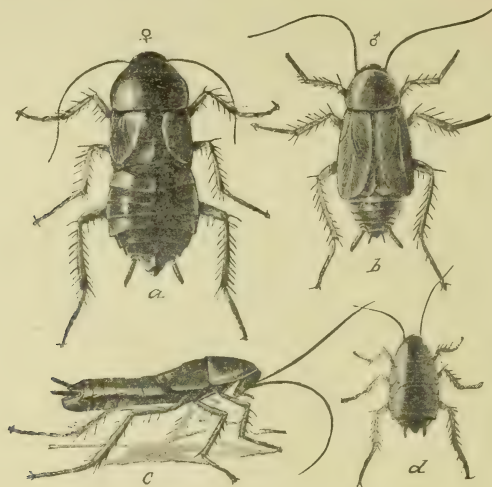


FIG. 4.—The Oriental roach (*Blatta orientalis*): a, Female; b, male; c, side view of female; d, half-grown specimen. All natural size (original).

of waterworks in New York City. It had probably been introduced long previously, but the extension of the waterworks system and of piping afforded it means of ingress into residences, and greatly encouraged its spread and facilitated its multiplication. The dampness of water pipes is favorable to it, and it may be carried by the pressure



FIG. 5.—The German roach (*Blattella germanica*): a, First stage; b, second stage; c, third stage; d, fourth stage; e, adult; f, adult female with egg-case; g, egg-case, enlarged; h, adult with wings spread. All natural size except g. (From Riley.)

of the water long distances through the pipes without injury. This roach has so multiplied in the eastern United States that it has now become the commonest and best known of the domestic species, and its injuries to food products, books, etc., and the disgusting results of

its presence in pantries, storehouses, and bakeries, give it really a greater economic importance than any of the other species.

It is very light brown in color, and characteristically marked on the thorax with two dark-brown stripes. It is more active and wary than the larger species and much more difficult to eradicate. It is the smallest of the domestic species, rarely exceeding five-eighths of an inch in length, and multiplies much more rapidly than the others, the breeding period being shorter and the number of eggs in the capsules greater than with the larger roaches. The injuries effected by it to cloth-bound reports have been the source of very considerable annoyance at the Department of Agriculture and in the large libraries of Eastern towns and colleges. The characteristics of the different stages, from the egg to the adult, are shown in the illustration (fig. 5).

NATURAL ENEMIES AND PARASITES.

In Europe the egg capsules of the cockroach are often parasitized by an ichneumon fly (*Evania appendigaster* L.). This insect has become widely distributed over the world following its host insect, and has been redescribed under a great many different names. It was found in Cuba as early as 1829, and has been several times collected in the United States. Unfortunately, its usefulness as a means of keeping the roach in check by destroying the egg capsules is greatly impaired by the occurrence of another ichneumon fly (*Entedon hagenowi* Ratzb.), which is parasitic upon the first. This is also a European species which has been brought over with its host parasite. If the true egg capsule parasite of the roach could have been introduced into this country without this secondary parasite its usefulness would doubtless have been very much greater. The secondary parasite, however, seems to have been introduced early, and has been found in Cuba and Florida, and probably occurs as widely as its host and prevents the latter from multiplying very greatly. Among other natural enemies of the roach are tree frogs; and a correspondent informs us that if these animals are inclosed in a room overnight they will effectively clear it of roaches.

REMEDIES.

Like the crows among birds, the roaches among insects are apparently unusually well endowed with the ability to guard themselves against enemies, displaying great intelligence in keeping out of the way of the irate housekeeper and in avoiding food or other substances which have been doctored with poison for their benefit. Their keenness in this direction is unquestionably the inheritance of many centuries during which the hand of man has ever been raised against them.

A thoroughly effective and simple means of ridding one's premises of roaches has been found, however, and is in fumigating with hydrocyanic-acid gas. The experience of the past few years has demon-

strated that this gas, formerly employed for disinfecting nursery stock and orchard trees (notably citrus) from scale and other insects, is equally effective against household insects, and is particularly applicable and satisfactory against all species of house roaches. The gas is extremely poisonous to human beings, but, with the proper precautions, may be employed with complete safety. A special circular (No. 46 of this series) has been prepared by Doctor Howard, giving the steps of the process in detail.

The means formerly employed against cockroaches, detailed below, are of value, however, and will be in order where fumigation may be deemed undesirable or is impracticable.

Poisons and repellents.—As just noted, roaches often seem to display a knowledge of the presence of poisons in food, and, notwithstanding their practically omnivorous habits, a very little arsenic in baits seems to be readily detected by them. In attempting to eradicate roaches from the Department storerooms where cloth-bound books are kept various paste mixtures containing arsenic were tried, but the roaches invariably refused to feed on them in the least. This applies particularly to the German roach, or Croton bug, and may not hold so strongly with the less wary and perhaps less intelligent larger roaches.

A common remedy suggested for roaches consists in the liberal use of pyrethrum powder or buhach, and when this is persisted in considerable relief will be gained. It is not a perfect remedy, however, and is at best but a temporary expedient, while it has the additional disadvantage of soiling the shelves or other objects over which it is dusted. When used it should be fresh and liberally applied. Roaches are often paralyzed by it when not killed outright, and the morning after an application the infested premises should be gone over and all dead or partially paralyzed roaches swept up and burned. Flowers of sulphur dusted about where roaches abound has proved, on the authority of Mr. A. I. Mudd, of this Department, very effective as a repellent.

There are many proprietary substances which claim to be fairly effective roach poisons. The usefulness of most of these is, however, very problematical, and disappointment will ordinarily follow their application. The only one of these that has given very satisfactory results is a phosphorous paste, sold in the form of pills. It consists of sweetened flour paste containing 1 to 2 per cent of phosphorus, and is spread on bits of paper or cardboard and placed in the runways of the roaches. It has been used very successfully in the Department to free desks from Croton bugs, numbers of the dead insects being found in the drawers every day during the time the poison was kept about. It is also a repellent.

Fumigation.—In addition to the hydrocyanic-acid gas treatment noted above, two or three other forms of fumigation may be employed against house roaches. Wherever roaches infest small rooms or apart-

ments which may be sealed up nearly air-tight, and also on shipboard, the roach nuisance can be greatly abated by the proper use of poisonous gases, notably bisulphid of carbon. This substance, distributed about a pantry or room in open vessels, will evaporate, and, if used at the rate of 1 pound to every 1,000 cubic feet of room space, will destroy roaches. Unless the room can be very tightly sealed up, however, the vapor dissipates so rapidly that its effect will be lost before the roaches are killed. The hatches of ships, especially of smaller coasting vessels, may be battened down, a very liberal application of bisulphid of carbon having been previously made throughout the interior. If left for twenty-four hours the roaches and all other vermin will unquestionably have been destroyed. In the use of this substance it must be always borne in mind that it is violently explosive in the presence of fire, and every possible precaution should be taken to see that no fire is in or about the premises during the treatment. It is also deadly to higher animals, and compartments should be thoroughly aired after fumigation.

A safer remedy of the same nature consists in burning pyrethrum in the infested apartment. The smoke and vapors generated by the burning of this insecticide are often more effective in destroying roaches than the application of the substance in the ordinary way as a powder. There is no attendant danger of explosion, and the only precaution necessary is to see that the room is kept tightly closed for from six to twelve hours. The smoke of burning gunpowder is also very obnoxious and deadly to roaches, particularly the black English roach. On the authority of Mr. Theo. Pergande, gunpowder is commonly used in Germany to drive these roaches out of their haunts about fireplaces. The method consists in molding cones of the moistened powder and placing them in the empty fireplace and lighting them. The smoke coming from the burning powder causes the roaches to come out of the crevices about the chimney and fire bricks in great numbers, and rapidly paralyzes or kills them, so that they may be afterwards swept up and destroyed. This remedy will only apply to old houses with large fireplaces, and has no special significance for the modern house. It is presented, however, as a means applicable wherever conditions similar to those described occur.

Trapping.—Various forms of traps have been very successfully employed in England and on the Continent of Europe as a means of collecting and destroying roaches. These devices are all so constructed that the roaches may easily get into them and can not afterwards escape. The destruction of the roaches is effected either by the liquid into which they fall or by dousing them with hot water. A few of the common forms of traps and the methods of using them are here described.

A French trap consists of a box containing an attractive bait, the

cover of which is replaced by four glass plates inclined toward the center. The roaches fall from the covering glasses into the box and are unable to escape. A similar trap used in England is described by Westwood. It consists of a small wooden box in which a circular hole is cut in the top and fitted with a glass ring, so that it is impossible for the roaches to escape. This trap is baited nightly, and the catch thrown each morning into boiling water. A simpler form of trap, which Mr. F. C. Pratt informs the writer is very successfully used in London, England, consists of any deep vessel or jar, against which a number of sticks are placed, and bent over so that they project into the interior of the vessel for a few inches. The vessel is partially filled with stale beer or ale, a liquid for which roaches seem to have a special fondness. In the morning these vessels are found charged with great quantities of dead and dying roaches, which have climbed up the inclined sticks and slipped off into the vessel. We have had fair success with this last method against the Oriental roach in Washington, but against the more wary and active Croton bug it is comparatively worthless.

Mr. Tepper, who has been quoted above in relation to the habits of roaches in Australia, gives a simple remedy which he says has proved very efficacious wherever employed. He mixes plaster of Paris 1 part and flour 3 or 4 parts in a saucer and places it where the roaches abound, with another flat plate near by containing pure water, both supplied with several bridges to give easy access, and one or two thin boards floating on the water touching the margin. The insects readily eat the mixture, become thirsty and drink, when the plaster sets and clogs the intestines. The insects disappear in a few weeks, the bodies no doubt being eaten by the survivors.

Traps of the sort described above, placed in pantries and bakeries, will unquestionably destroy great quantities of roaches, and keep them, perhaps, more effectively in check than the use of the troublesome insect powders or the distribution of poisoned baits, especially as the latter are so often ineffective.

Approved :

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *June 23, 1908.*

CIRCULAR NO. 52, SECOND SERIES.

United States Department of Agriculture,

DIVISION OF ENTOMOLOGY,

L. O. HOWARD, Entomologist.

THE LIME, SULPHUR, AND SALT WASH.

By C. L. MARLATT,

Entomologist in Charge of Experimental Field Work.

USE AGAINST THE SAN JOSE SCALE IN THE EAST.

The experiences of the last two years with the use of the California, or lime, sulphur, and salt, wash in the East have been in many cases of so satisfactory a nature as to cause numerous letters of inquiry, and indicate the need of a special circular of information. This wash is described and recommended in Circular 42 (second series) of this office, relating to treatment for the San Jose scale, and also in Farmers' Bulletin 127 on insecticides. But in these publications the information is very concisely given and none of the experiments on which are based the recommendations for the East are described. It is proposed in this circular to give a brief history of the employment of this wash in the East and to make such recommendations as the results justify.

EARLY TESTS IN MARYLAND.

With the discovery of the San Jose scale in Eastern nurseries and orchards the first thought naturally was to employ against it the washes which were very commonly used for its control in California and other Pacific coast regions. The results of the preliminary tests are recorded in the first general publication of this office on the San Jose scale, namely, Bulletin 3 (new series), pp. 57-71. Among many other tests made the lime, sulphur, and salt wash as used in California, and the Oregon wash, a slight variation of the latter, were the subject of careful experiments. This work was done by the writer, assisted by Mr. Coquillett, who while the California agent of this Division, had employed the lime, sulphur, and salt wash in many combinations and was thoroughly familiar with its use on the Pacific coast.

HOW THE WASHES WERE PREPARED.

The washes referred to were made after the following formulas:
California wash.—Lime, unslaked, 40 pounds; sulphur, 20 pounds; salt, 15 pounds. Add 40 gallons of water to the above materials, stirring thoroughly while the lime is slaking. Boil fully three

hours, then add enough water to make 80 gallons of the solution. Strain through burlaps and apply milk warm, using only on deciduous trees and when the said trees are dormant. This formula is that given by Mr. H. B. Muscott, then chairman of the San Bernardino County Board of Horticultural Commissioners, who reported that the wash was prepared by a practical chemist employed by the commissioners and furnished at cost in concentrated form, and was extremely successful. A description furnished by H. P. Stabler, of Yuba City, Cal., of the method of making the California wash by means of a twelve-horsepower boiler and attached pipes and hot water tank was also given, an apparatus by means of which 300 gallons of the wash could be prepared at one time.

Oregon wash.—Sulphur, 15 pounds; slaked lime, 15 pounds; bluestone, $1\frac{1}{4}$ pounds; water to make 100 gallons. Prepared in the same way as the California wash. This mixture is interesting as representing a distinct variation in ingredients. It has little if any excess of lime, and the bluestone, which takes the place of the salt, probably does not add to the value as an insecticide and increases the difficulty of preparation. It is little employed.

RESULTS OF THESE TESTS.

The trial with these two washes was made November 17, 1894. They were used on peach and other fruit trees at the strength recommended in California and Oregon, and also at double this strength. The treated trees were carefully examined a month later, December 15, and only a very small percentage of the scales were found affected, not more than on untreated trees. The same results were seen with both strengths; in other words, the double strength was no more effective than the ordinary strength used on the Pacific coast. The trees were still whitened with the wash. These conditions had not changed at the time the orchard was given the general spraying with soap toward the end of April, 1895, which prevented following the action of these washes further.

INEFFECTIVENESS BELIEVED TO BE DUE TO CLIMATE.

The explanation which naturally suggested itself for the apparent failure of these Pacific coast washes to be effective in the East was in the difference in the climate between the two regions, and especially as earlier experiments (January–March, 1894) with the lime, sulphur, and salt wash conducted by the writer against the so-called West Indian peach scale (*Diaspis pentagona*) had shown similar unsatisfactory results.¹ In California these washes are applied in the dry season, and a long period may follow without rain. In the East a period more than

¹ Insect Life, Vol. III, pp. 118–119.

plete extermination of the San Jose scale on these trees. This it is an important one and should not be overlooked in making estimates of the effectiveness of washes.

THE WASH AN AVAILABLE REMEDY FOR THE EAST.

The advantages of the California wash are notable. It is inexpensive, costing but little above one cent per gallon for materials, and does not entail any danger to the plant treated. Its disadvantages are the difficulty of preparation and heavy wear which it entails on apparatus, and actions, however, which do not offset its advantages if future experience confirms the more recent results. The danger in careless hands and the use of petroleum oils, also their expense, and the great expense of soap washes, bring this lime, sulphur, and salt wash into especial prominence and recommend it to all who are so situated as to prepare easily. This does not, however, discredit in the least the other washes mentioned.

COMPOSITION AND PREPARATION OF THE WASH.

The report of the Department Chemist (given in footnote on page 4) states sufficiently clearly the compounds entering into this wash and the behavior of these, respectively, in dry and moist climates. It is evident that in all the formulas, both those recommended above and others (practically every experimenter making a formula of his own), there is a great excess of lime which adds to the lime coating on the plant, and doubtless has its benefit as a deterrent. The composition of the wash is a matter of some indifference. I believe the formula followed in the experiments just described and recommended in Circular No. 1 is a good one to follow. This wash gave perfectly satisfactory results against the San Jose scale and is less wasteful in ingredients than many others, although still containing a considerable excess of lime, but perhaps not more than is desirable. The action of the salt is not very well known, and it is possible that this element could be eliminated, as indicated by some recent tests, without affecting the results of the treatment. Salt is, however, used in whitewash to give adhesiveness, and may act in the same way in this wash, causing it to adhere longer and better than would be the case without it.

The wash is practically a sheep dip¹ imported into California, I believe, from Australia, and with the advent of the San Jose scale emerged with little change against this insect, and by a lucky chance proving effective.

Prolonged and hard boiling increases the percentage of the higher saponins, although in the main the liquid will consist of the simpler

or sheep dips recommended by the Bureau of Animal Industry of this Department, see Bulletin 21, B. A. I.

hours, then add enough water to make 80 gallons of the solution. Strain through burlaps and apply milk warm, using only on deciduous trees and when the said trees are dormant. This formula is that given by Mr. H. B. Muscott, then chairman of the San Bernardino County Board of Horticultural Commissioners, who reported that the wash prepared by a practical chemist employed by the commissioners was furnished at cost in concentrated form, and was extremely successful. A description furnished by H. P. Stabler, of Yuba City, Cal., of the method of making the California wash by means of a twelve-horsepower boiler and attached pipes and hot water tank was also given, and a ratio by means of which 300 gallons of the wash could be prepared in one time.

Oregon wash.—Sulphur, 15 pounds; slaked lime, 15 pounds; bluestone, $1\frac{1}{4}$ pounds; water to make 100 gallons. Prepared in the same way as the California wash. This mixture is interesting as representing a distinct variation in ingredients. It has little if any excess of lime and the bluestone, which takes the place of the salt, probably does not add to the value as an insecticide and increases the difficulty of preparation. It is little employed.

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compounds of lime and sulphur; and from this fact it is to be inferred that these latter are by themselves effective, although a slight increase in efficiency may be gained by increasing the higher sulphids.

When making this wash in quantities of 50 gallons and upwards, it is necessary to boil for three to five hours, and especially at the start it should be stirred up thoroughly to prevent caking. In the process of making, the color changes from a yellow to the clear brown of sulphid of lime except for the excess of lime floating in it. It may be prepared by boiling in an ordinary vat of iron or, preferably, copper; or, is much more satisfactorily made by boiling in big hogsheads or barrels with steam. Where the wash can be prepared in the latter manner, its use is to be strongly recommended. It may then be made up at once with the full amount of water, and taken hot from the boiling tank and promptly applied so as to get the advantage of the higher sulphids and the full strength of the mixture. In transferring to the spray tank, pass it through an iron strainer. The spray tank must be provided with an effective agitator. The experiments of 1900, quoted above, discuss the matter of temperature fully. In important fruit districts it would be well worth while to adopt the plan followed very commonly in California—of organizing spraying companies to undertake at a reasonable charge the preparation of the wash and the spraying of orchards. In California the wash is furnished and put on the trees, everything included, at a charge of five cents per gallon.

PRECAUTIONS TO BE NOTED.

This wash is a winter application and can not be applied to trees in leaf. The best season is February or March. The fact that this wash is destructive to pumps and nozzles has already been indicated. The injury in this direction can be reduced to a minimum by carefully cleaning the pump each night with water. The Vermorel nozzle is the best one for the wash, and additional caps may be secured to replace worn ones. The use of an air pump instead of a liquid pump would save the wear of the lime on the pump; and doubtless our Eastern manufacturers could be induced to make a suitable apparatus of this sort. In spraying with this wash clothing is ruined, and only the oldest garments should be worn, and care should also be taken to protect the eyes to avoid unnecessary inflammation. There is, however, no special danger.

Approved:

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *February 20, 1903.*

CIRCULAR NO. 53.

United States Department of Agriculture,

DIVISION OF ENTOMOLOGY,

L. O. HOWARD, Entomologist.

THE YELLOW-WINGED LOCUST.

(*Camnula pellucida* Scudd.)

By C. B. SIMPSON,

Investigator, Division of Entomology.

For many years past the yellow-winged locust, *Camnula pellucida*, has been a pest of the greatest importance in certain agricultural sections of Idaho and Utah. Its injuries are so great that the natural development of these sections is seriously interfered with, and often crops are almost a total loss. This insect is quite generally distributed over the northern portion of the United States, but is injurious only in comparatively few localities in the West.

It is quite variable in color, ranging from light yellow to brown, with all gradations between. The males are always smaller than the females, and can be easily distinguished by the difference in the end of the abdomen, which is more or less rounded in the male, while in the female it ends with four horny points. The nymphs or young locusts are of a dark color, sometimes almost black. The young locusts depend entirely upon their legs for locomotion, as the wings in the earlier stages consist only of small pads.

The life history of this insect is not

so well known as that of many other injurious species. The eggs are laid in the ground during August in pod-like sacs containing from 20 to 30 eggs each. The female usually chooses sandy or gravelly spots in which to deposit eggs. In the latter part of May and in June the eggs hatch, and in about a month the locusts become full grown and winged and begin to migrate, and if in sufficient numbers they strip the vegetation in their path. Many of them remain along the path of migra-

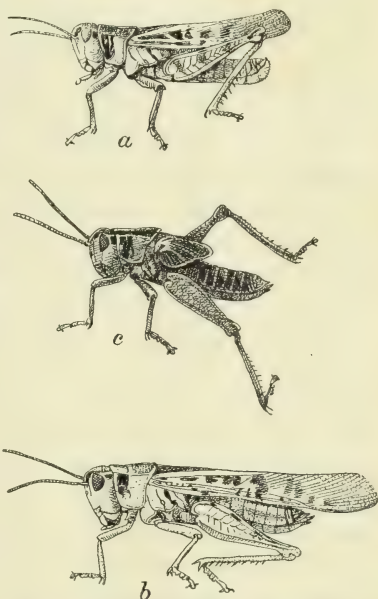


FIG. 1.—The yellow-winged locust (*Camnula pellucida*): a, adult male; b, female; c, nymph—somewhat enlarged. (Original.)

tion and deposit their eggs, and thus cause several years of abundance. In a few sections they are numerous enough to cause great damage only three or four years out of every ten.

This locust is a general feeder, and is especially destructive to hay, oats, and wheat, the principal crops grown in these sections. Apparently the insect dislikes alfalfa, as this crop is usually but little injured.

REMEDIAL MEASURES.

The application of remedial measures against this pest depends largely on the locality in which the pests are at work, and every possible advantage should be taken of the natural surroundings. The breeding grounds must be accurately located; and if there are periods of years in which the insects are few in numbers and consist of scattering colonies, these colonies should be located and destroyed as a preventive measure. Many methods have been devised to combat the insect when it has reached the adult or winged stage, but at best these measures are very expensive, and are in most cases of but little value. If success is to be obtained in the destruction or control of this insect, it must be attacked in its breeding grounds, either when it is in the egg stage or before becoming winged.

Plowing.—By observing the insects during the egg-laying period, or stirring the ground and exposing the eggs, the breeding grounds can be easily located. By plowing these grounds in the fall many of the eggs are buried so deep beneath the ground that when the young hatch in the following spring they perish because they can not reach the surface. Others are killed by exposure to the weather, and their numerous enemies have a better opportunity to feed upon them.

Spraying with oil.—In many sections of the West, where crude petroleum can be obtained at very little cost, the method of spraying with oil has been found very successful. The petroleum is sprayed over the breeding grounds upon the young locusts, which are killed by contact with the oil. The effectiveness of this treatment depends primarily upon the thoroughness with which it is applied. Additional effectiveness can be secured by burning over the ground after it has been sprayed, as this will kill those which have escaped the spray.

Hopperdozers.—Hopperdozers are long, shallow pans of any convenient dimensions, made of galvanized iron or other material mounted upon runners about an inch thick. The pan is partly filled with water, a small quantity of kerosene is added to form a film, and a screen is placed upright on the back to prevent the locusts from jumping over the pan. As hopperdozers are drawn over the ground by either men or horses, the young locusts jump into the air, fall into the pan, and are wetted and killed by the kerosene. This method has been found to be less effective against this insect than against locusts of other species. Sage brush in the breeding grounds often renders it difficult to use the

hopperdozers, and it is quite necessary to drive or sweep the young locusts of this species into the pan when it is drawn along, as but comparatively few of them jump high enough to fall into it.

Poisoning.—Poisoning the young locusts with arsenicals has been found to be one of the most effective measures that can be used against this insect. There are many mixtures which are very effective, but the greatest success has been obtained by a combination of arsenicals and fresh horse droppings. One pound of Paris green, or some other convenient arsenical, together with 2 pounds of salt, are thoroughly mixed with 60 pounds of fresh horse droppings. The resulting mixture is scattered among the young locusts or around the edges of fields which it is thought may be invaded. A very convenient receptacle in which to make this preparation is a half-barrel. A trowel or paddle can be used in scattering the mixture in the desired places.

The importance of beginning work against the younger stages can not be too strongly emphasized, because little can be done to destroy these locusts after they have wings and have begun their migrations by short flights. By means of a voluntary organization of farmers, a general survey of a locality in the fall, aided by the experience of previous years, will render it comparatively easy to forecast if the locusts will be abundant the ensuing season. During the years when they are few, a small amount of work will keep them within bounds, or by more extended work they may be nearly exterminated. Climatic conditions, parasites, and diseases, although often effective, can not be relied upon, and it is necessary that well directed and persistent campaigns be undertaken if success is to be obtained.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *May 12, 1903.*

United States Department of Agriculture,

DIVISION OF ENTOMOLOGY.

L. O. HOWARD, Entomologist.

THE PEACH-TREE BORER.*

(Sannina exitiosa Say.)

By C. L. MARLATT,

Entomologist in Charge of Experimental Field Work.

GENERAL APPEARANCE AND METHOD OF WORK.

The brownish, gummy exudations, more or less soiled with earth and the larval excrement, about the bases of peach trees, and also, to a less extent, of the cherry and plum and other stone fruits, are familiar to

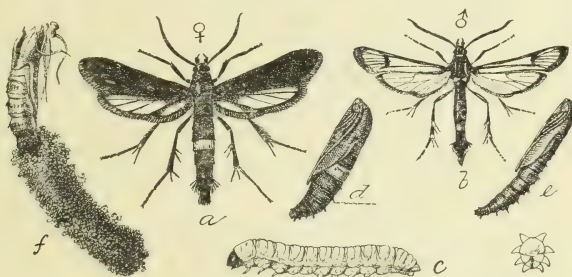


FIG. 1.—*Sannina exitiosa*: a, adult female; b, adult male; c, full-grown larva; d, female pupa; e, male pupa; f, pupa skin partially extruded from cocoon—all natural size (original).

all growers. These exudations indicate the presence of the peach-tree borer, which undergoes its development just within the bark, mining between the bark and the sapwood, often completely girdling and causing the death of trees, and always greatly injuring and weakening them. The parent of this larva is not often seen. It is a very slender, dark-blue moth, wasp-like in appearance, and presenting remarkable differences between the two sexes. The mimicking of the wasp is especially noticeable in the case of the male insect, the wings of which are transparent, bordered with steel-blue, which is the general color of the body in both sexes. The fore-wings of the female are blue and clothed with scales, while the hind-wings are transparent, resembling those of the male. The middle of the abdomen of the female is marked by a broad orange band covering the fourth, or fourth and fifth segments. The male expands about one inch and the female an inch and a half or more.

ORIGIN AND DISTRIBUTION.

The peach-tree borer is a native species, and was described by Thomas Say, of Philadelphia, early in the last century. It had then been

*This circular replaces No. 17, new series.

known, however, as the peach-tree pest for nearly one hundred years. Its food plant prior to the introduction of the peach by Europeans was undoubtedly some of the wild cherries or plums of the Northeastern States. In other words, it is an Eastern species, and has followed the cultivated peach into the Middle and Western States. On the Pacific coast there is a closely allied species (*S. opalescens*) which takes its place as the important enemy of stone fruits. The Eastern species early attacked the cultivated peach and other stone fruits in New York and New Jersey. It is now widely distributed and is a common and perhaps the most important pest of these fruits in all the regions where they are grown east of the Rocky Mountains. Although it has been carried to the Pacific coast on nursery stock a good many times and obtained temporary foothold there, it does not seem to have ever permanently established itself in that region. The Pacific coast species named above is often confused with the Eastern species, but the two are quite distinct, although the habits and means of control are substantially the same for both species. This circular deals, however, with the more important Eastern species.

NATURAL HISTORY AND HABITS.

There is but one generation of larvæ annually. The moths appear as early as May in the latitude of Washington, D. C., and southward, over what approximates the lower austral region. In the upper austral region, roughly comprising the States above the cotton belt and below the northern tier, the moths do not appear until after the middle of June. In the transition region, which comprises the northern tier of States, together with most of New York and New England, the moths appear chiefly in July and later, emerging, however, as early as June, and belated individuals as late as October. June and July are therefore the months when the moths are the most numerous over the principal peach districts.

The egg is deposited on the bark, usually at or near the surface of a ground, although rarely it may be placed well up on the trunk or in the crotches of the larger branches. The egg is very minute, not exceeding 0.2 mm. in length, oval, yellowish brown in color, and irregularly ornamented with hexagonal sculpturing. The young larva on hatching is very active, and immediately burrows into the bark, usually entering at a crack. Having worked its way to the sapwood, usually near or below the surface of the ground, it feeds steadily during the balance of the summer and well into the fall, constantly enlarging its excavation, and causing the exudation of the gum intermixed with excrement and fragments of bark, which is so characteristic of its presence. It remains dormant in the larval state during winter and resumes feeding again the following spring, reaching full growth in the central districts by the middle of June. It transforms to chrysalis within an elongate, cocoon-

like cell constructed of its own frass and particles of bark attached with gum and threads of silk, and remains in this stage some three weeks. The males appear a few days earlier than the females.

The full-grown larva attains a length of about an inch, is rather robust, of a yellowish white color, with head and first segment brown.

PREVENTIVE MEASURES.

There is a great diversity of opinion as to the merits of the various preventive measures which have been suggested and practiced by different growers or economic entomologists and the results obtained by different individuals and from different regions are very much in conflict. This is doubtless to be explained by the differences in climate, care of application, or details of treatment which do not appear in the published accounts. One is not, therefore, obliged to discard a method as useless because some one experimenter has difficulty with it, but under such circumstances it is always advisable to make a careful preliminary test with a few trees before making a general application to an orchard.

Of the numerous mechanical and similar methods of preventing damage by the peach-tree borer the oldest and still one of the best is the process of mounding up earth about the trunks of the trees to a height of ten or more inches early in June and removing it again in the fall. This method is inexpensive and will protect the trees from a large percentage of the borers. It has been followed for nearly a hundred years, but perhaps it is not used now as much as formerly. As pointed out by Slingerland, it is especially of value in the case of nursery stock, where more artificial and possibly more efficient applications are impracticable.

Of the same order is the method recommended by Harris as early as 1826, which consists in removing a little of the earth from about the base of the tree and surrounding the trunk with a strip of sheathing paper 8 or 9 inches wide and extending 2 inches below the soil, secured with strings above and by replacing the soil about the trunk below. Any heavy paper or tarred roofing paper will answer the purpose. These wrappings may be removed in winter and renewed in June.

The idea of a more durable wrapping of this sort early suggested itself, and the late Dr. Lintner was perhaps the first to experiment with wire netting. Cylinders of window screen wire 15 inches in height were tied about the trees very much as the paper applications mentioned above. More careful experimentation in late years, especially by Mr. Slingerland, has demonstrated that wire netting is of no protection whatever, for, while the eggs can not be laid on the trunk by the moths, young larvæ have no difficulty in crawling down from higher situations and gaining the usual position about the base of the tree.

To overcome the weak features of the wire screen netting, Prof. J. M. Stedman, of the Missouri experiment station, has employed a band of thin boards, which are securely wrapped and tied about the trees, the upper exposed end being stuffed with cotton about the trunk to prevent the larvæ from penetrating within the screened portion. This, in Professor Stedman's hands, has given excellent results, but in the hands of Mr. Slingerland the results were no better than with the wire screen.

Tying rye or other straw about the trunks has often been recommended and employed. It also has the objection of not affording very perfect protection on account of the possibility of the larva penetrating through straw and getting to the base of the trunk.

Another order of preventive applications are limy coatings to the bark, poisoned or otherwise, all of these applications extending from a few inches below the surface of the ground to a height of a foot or 18 inches, or, in the case of these lime coatings, even up to the lower branches. Some of these lime applications have had substances added to them to make them obnoxious to the moths, as, for instance, carbolic acid. Perhaps the best of these is the wash recommended by Mr. J. H. Hale. Two quarts of strong soap and a half a pint of crude carbolic acid, with 2 ounces of Paris green, are thoroughly incorporated in a bucketful of water and enough lime and clay added to make a thin paste. This application, in the hands of its originator and others, has given very good satisfaction, two applications, however, being sometimes necessary to get the best results. As will be noted, it contains a small amount of Paris green. The application of a reasonable amount of this poison to the trunk in combination with the lime is attended with no risk to healthy plants. Other mixtures containing arsenicals which have a glue or a paint base have proven injurious to the trees, and no strong arsenical application should be made to the trunk of the peach tree. The difficulty with the lime applications is that they are rather unstable in a climate where rainfalls are comparatively frequent and abundant; and, furthermore, if put on as a very thick wash, they are apt to crack and leave openings for the larvæ.

Gas tar was early recommended as a means of preventing damage by the peach-tree borer. The experience with it has been of a very contradictory nature however. It has been very successfully employed for a number of years by Mr. Slingerland, who gives it his unqualified endorsement as perhaps the best method of preventing damage by this insect. On the other hand, as noted, gas tar has been used by other experimenters with disastrous results to the life of the trees. There is no doubt, from Mr. Slingerland's work, that gas tar, lightly and properly applied to the trunk of the tree, will not endanger the health of the plant, at least under the conditions of temperature and moisture obtaining at Ithaca, N. Y. Its careless application, however, will probably result disastrously and it may be less safe in regions with moist and hot

summers. In using this substance, therefore, one should first experiment with a few trees to be sure that a method is not adopted that will do material damage to the orchard. The ordinary gas tar is employed, heating it slightly so that it may be painted readily on the bark. Mr. Slingerland's experience showed that it freed the trees from four-fifths to all of the borers, but a small percentage of the trees becoming infested. All of these applications should be made early in June, or before the moths are out.

In addition to the above, a very large number of substances have been experimented with including all which seemed to offer any likelihood of preventive value. Of these, those named above have yielded the best results.

REMEDIAL MEASURES.

The methods just outlined are preventive and are designed to keep the peach-tree borer from ovipositing or to destroy the young larvæ before they have entered the bark. After a tree is once infested these external applications are of no avail, except to prevent additional attack. To kill the larvæ in the trees two or three methods may be followed. The old-time process of digging or cutting the larvæ out with a knife is undoubtedly the most effective and useful of all means of controlling the peach-tree borer, and is followed by some orchardists altogether, no effort being made to protect the trees from attack, reliance being placed solely in the removal of the larvæ in autumn or summer.

In California the related peach-tree borer referred to in the opening paragraph has been effectively controlled by the use of bisulphid of carbon. This substance has given very satisfactory results as reported by Prof. C. W. Woodworth; but, on the other hand, in the case of experiments made with it in New York by Mr. Slingerland, it proved a complete failure, and was condemned by him on account of its cost and its being dangerous to the health of the tree, and, at the same time, ineffective as a means of destroying the borer. Its efficiency depends a great deal on the character and condition of the soil, and, taking the difficulty of determining and controlling this into account, and also the other objections to it, namely, cost and danger to the trees, it seems not a method to be generally recommended.

Douching the bases of the trees copiously with boiling hot water will also destroy the larvæ, but this entails the transporting of quantities of water kept at the boiling point through the orchard, and on a large scale is rather impracticable.

The digging out process, therefore, remains the simplest and most efficient. It entails very little expense, and after some experience can be done rapidly and with very little injury to the tree. The peach tree grows very rapidly, and any wound occasioned by cutting out some of the bark to get at the larvæ readily heals over and, at any rate, the

damage is already done by the larvæ and is not very much increased by this treatment. Within certain limits one can take the most advantageous time for this work. The larvæ are small in the autumn and are located with greater difficulty than they are in early summer. During the winter they are hibernating, and the damage at this period is therefore at the lowest ebb. April or May is a good season for the work, as attended to then it prevents the early summer feeding. It will be advisable, however, to go over the trees again in June to pick up any of the larvæ which may have escaped the earlier examination. In June they are easily located by the larger size of their castings and pupal cases. To be effective this method should include not only the commercial orchard, but all old peach, cherry, and plum trees in yards or fields in the vicinity.

In conclusion, it may be said that the peach-tree borer is one of the most difficult pests to control, and no one method probably will give complete freedom from it. Mounding, paper wrapping, or the deterrent washes should therefore be combined with the digging-out process, and if these are kept up as a regular yearly procedure this pest should be easily kept under, and the amount of labor entailed, especially in the digging-out work, should steadily diminish.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *October 19, 1903.*

United States Department of Agriculture,

DIVISION OF ENTOMOLOGY,

L. O. HOWARD, Entomologist.

POWDER-POST INJURY TO SEASONED WOOD PRODUCTS.

By A. D. HOPKINS,

In Charge of Forest Insect Investigations.

INTRODUCTION.

The so-called powder-post injury to seasoned wood has attracted much attention in America, and especially in Europe for centuries, and has been the subject of published articles in many languages.

This peculiar injury seems to be on the increase in the United States and numerous requests from a number of the principal manufacturers of vehicles and wooden articles have recently been addressed to this office for information. The subject has received considerable attention through Mr. F. H. Chittenden and the writer in the past, and investigations are now being made with a view to publishing a special bulletin giving detailed information. It is deemed advisable, however, to issue this circular in advance, as it is addressed especially to our correspondents who are in need of immediate information.

CHARACTER OF POWDER-POST INJURY.

Fine, flour-like powder is found on or beneath piled or stored hickory, ash, oak, and other seasoned hardwood products. Upon closer examination small holes will usually be found in the surface of the wood from which the powder will fall when moved or jarred. By cutting into the wood, or splitting it, the interior is often found converted into a mass of closely packed material which readily crumbles into powder. This is held together by an outer thin shell and intervening fibers of sound wood. It will also be found that the injury is confined to the white or sapwood, and that the darker-colored heartwood is seldom, if ever, thus affected.

CHARACTER AND EXTENT OF LOSSES.

This form of injury is widely distributed over the world, and unless remedies are instituted the resulting loss will be great. This is especially so in a country like the United States, which is rich in hardwood forest resources, and where there are extensive interests in the manufacture of commercial products from such wood. It is a character of loss which falls directly on the dealer, the manufacturer, or owner of

finished products, rather than on the producer of the crude product, since it is only after the wood is seasoned, and often some years after it is taken from the tree, that it is seriously affected. The principal losses result from injury to old hickory, ash, oak, and other dry hardwood lumber; handles, spokes, and other sapwood material used in vehicles of various kinds; ornamental woodwork, furniture, inside hardwood finishings, floors, joists, and frame timbers; inside rustic work, hoop-poles, bamboo, wood specimens in museums, old tanbark, and many other similar articles. In many cases the affected articles are not only rendered worthless for the purposes for which they are intended, and in the aggregate cause direct financial loss amounting to hundreds of thousands of dollars, but in certain cases may be a menace to human life, as in weakened construction timbers in floors, frames, bridges, and wood material of vehicles, etc. Indeed, we have evidence of a railroad wreck in which many lives were lost, due to powder-post injury to the principal construction timbers.

CAUSED BY INSECTS.

The injury with the consequent losses mentioned is the work of several kinds or species of insects which have the peculiar habit of burrowing into seasoned wood in quest of their natural food supply of nutritive substances in the wood, which is apparently rendered especially attractive by the loss of moisture and the chemical changes brought about by the seasoning process and the increased age of the dry material.

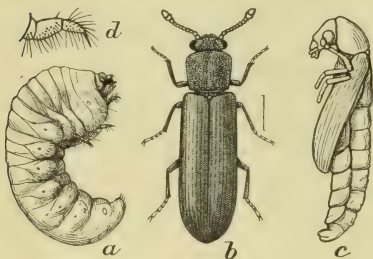


FIG. 1.—A powder-post beetle (*Lyctus planicollis*): a, larva; b, adult; c, pupa; line to right of adult represents natural length (Chittenden).

Character of the insects.—The adults or winged forms of this class of insects are small, slender or stout, brownish to nearly black beetles, which upon

emerging from the wood where they breed and pass the winter, fly or crawl about in search of suitable wood material in which to deposit their eggs.¹

Habits and life history.—The different species vary in their habits and life history, from the egg to the adult, but in general that of the true powder-post beetles is as follows: The winter is passed in the wood. The eggs are deposited under normal conditions soon after activity commences in the spring, while in store-houses and buildings kept warm and dry they may continue their activity through the year

¹Technically the insects which have this peculiar habit belong to the order Coleoptera, and chiefly to the families Lyctidæ, Ptinidæ, and Bostrichidæ. By far the larger part of the injury is caused by species of the genus *Lyctus*, of which there are several forms.

and deposit eggs much earlier. The minute white "worm" or grub (the second stage of the insect known as the larva), upon hatching from the egg, proceeds to burrow in and through the wood in all directions, feeding and growing as it proceeds, until it has attained its full growth. It then excavates a cell at the end of its burrow, in which it transforms to a semi-dormant stage (the pupa, or third stage in the insect's life), remaining thus until the legs and wings have fully developed, when it bores its way out and appears as the matured adult or beetle (the fourth stage), to mate and repeat the life process. Under normal conditions, so far as we positively know, there is probably only one generation annually.

Each female deposits many eggs, and many females oviposit on or in a single piece of wood, so that the combined work of their numerous progeny, burrowing through the wood in quest of food for their development, results in the complete destruction of the interior wood fiber and its conversion into a mass of fine powder. If the first attack and the first generation do not accomplish this destruction, subsequent generations will follow in the same wood until nothing of the solid fiber is left but a thin outer shell.

FAVORABLE CONDITIONS FOR ATTACK.

The conditions which appear to be most favorable for inducing attack are perfectly dry wood material, or sapwood which has been stored or piled in one place for two, three or more years, manufactured articles which have attained considerable age, floors and frame timbers in old houses, and other wooden structures. The insects prefer such material before it has been painted, varnished, or otherwise treated, but it appears that certain species will, in rare cases, even attack old wood which has been painted or varnished.

METHODS OF PREVENTING LOSS.

The methods of combating this class of insects, and of preventing losses from their ravages, come under two primary heads: *First*, destruction of the insects; *Second*, prevention of attack.

Destruction of the insects.—In the case of lumber and other manufacturers' and merchants' supplies which are found to be infested, the entire stock should be gone over carefully, and every piece showing the least indication of injury sorted out. Every piece found to be so injured that it is of no value, should be removed and immediately burned, together with all waste pieces of wood, lumber, sticks, and other useless material which might serve as breeding places for the insects. Thus vast numbers of the insects will be destroyed. October to March is probably the best time in which to do the work, in order that none may escape. All partially damaged material, such as the sap edges of lumber, and parts of other material too valuable to destroy,

should, when practicable, have the damaged and infested parts removed, and likewise burned.

Where it is not practicable to remove the infested parts, the material may be subjected to one or more of the following methods for the destruction of the insects, and the prevention of further attack, provided in each case the treatment is not detrimental to the wood for subsequent uses:

1. A liberal application of pure kerosene, benzine, gasoline, formalin, brine, or like substances, to the infested parts.
2. Thorough steaming of the wood in a tight room.
3. Subjecting the wood to the highest practicable dry heat in a dry kiln.

In the case of finished products such as furniture, museum specimens, and the like, which are portable, they may be subjected to the treatment mentioned under "1," "2," and "3," selecting the one which is least injurious to the articles. In the case of painted or varnished articles which would be injured by external treatment, the liquid may be injected into the holes made by the insects, or in small gimlet holes made for the purpose, to be afterwards filled with putty. With inside hardwood finishings, such as wainscoting, staircases, floors, doorposts, and the like, the injection of the liquid is perhaps the only practicable method of checking the progress of the injury.

When infested construction timbers are badly damaged, or important parts are weakened by the work of the insects, they should be removed and replaced by sound heartwood material, while all slightly damaged accessible wood should be treated with an external or internal application of a suitable liquid remedy.

Methods of preventing attack.—In the case of lumber and other manufacturers' and merchants' supplies, the following precautions should be taken to prevent the introduction and subsequent multiplication of the insects, as well as to prevent the development of favorable conditions for their attack.

To accomplish this end a general cleaning up and the immediate destruction of all useless and infested material, and the proper treatment of the slightly injured and infested wood, is of primary importance. Special precautions should also be taken as follows:

1. To prevent the introduction into the lumber-yards, store-houses, and factories, of infested material, remembering that the insects may be thus carried to or from all parts of the world in wooden articles.
2. The fact that the older material forms the most attractive conditions for the attack of the insect, suggests the importance of preventing the accumulation of such material by converting it into the finished products within two or three years, or less time, after it is taken from the tree.

3. To make semiannual inspections of the lumber-yards and store-houses in order that any evidence of the presence of the insect may be promptly detected, and the infested pieces removed for treatment.

4. Nothing but heartwood lumber sticks should be used in piles of lumber liable to attack.

5. Quantities of naphthaline scattered about over the piles of lumber and other material, two or three times during the year, would serve to keep the insects away.

6. No wood showing the slightest indication of powder-post should ever be used for a finished article, or for parts of a building or other structure.

7. All important timbers used in wooden structures should be entirely free from sapwood.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *November 20, 1903.*

NOTE.—If correspondents who try any of the methods recommended in this circular will notify the Division of Entomology of the results of their experience, and offer suggestions from their practical business for experiments or lines of investigations, it will aid materially in making our future publications of special practical value to the interests involved.

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist.

**THE MOST IMPORTANT STEP IN THE CULTURAL SYSTEM OF
CONTROLLING THE BOLL WEEVIL.**

By W. D. HUNTER,

In Charge of Cotton Boll Weevil Investigations.

The agitation of the necessity for procuring an early crop in order to avoid damage by the boll weevil has been carried on to such an extent by the Department of Agriculture that the details have become common knowledge. There is, however, a tendency on the part of many planters to lose sight of the fact that procuring an early crop is but one step and is strictly secondary to the great essential step, namely, the destruction in the fall of the plants in the field. As a matter of fact, early planting, the use of early varieties, and the use of fertilizers, are simply to further the advantage gained by the process of fall destruction.

REASONS FOR THE DESTRUCTION OF THE PLANTS IN THE FALL.

There are four principal reasons why the process of fall destruction recommended in this circular should be practiced universally by planters in infested regions.

First.—Fall destruction prevents absolutely the development of a multitude of weevils which would otherwise become adult within a few weeks of the time of hibernation. The destruction of the immature stages of weevils in infested squares and bolls is accomplished, while the further growth of squares which may become infested later is also prevented. This stops materially the development of weevils which would normally hibernate successfully, and by decreasing the number of weevils which will emerge in the spring the chances for a successful crop the following season are very greatly increased.

Second.—A proper manipulation will bring about the destruction of a great majority of the weevils which are already adult.

Third.—It has been shown conclusively that the only weevils which survive the winter are those which reach maturity late in the season. Those maturing earlier are unable to survive the long period of hibernation. In one instance, out of 240 weevils taken from the field at the middle of December and placed in hibernation, 38, or 15.8 per cent, passed the winter successfully, while out of 116 which became adult about November 15, only 1, or less than 1 per cent, survived. It is evi-

dent that the weevils that pass the winter and attack the crop the following season are among those developed latest in the fall and which, in consequence of that fact, have not exhausted their vitality by depositing eggs for any considerable length of time. Fall destruction of the plants, thereby increasing the length of the hibernating period, will undoubtedly cause the reduction by many fold of the number of weevils in the fields that would otherwise emerge in the spring to damage the cotton.

Fourth.—Clearing of the field in the fall makes it possible to practice fall plowing, which is not only the proper procedure in any system of cotton raising, but also greatly facilitates the early planting of the crop the following spring. The ground becomes clean by this practice, so that but few places for shelter are left for the weevils, and various climatic conditions still further reduce the numbers of the survivors.

TIME FOR DESTRUCTION OF THE PLANTS.

It is naturally impossible to fix any date for the destruction of the stalks which would apply to all localities and under all conditions. The condition of the soil must be considered as well as the maturity of the crop. While the condition of the soil can not be controlled, the time of the maturity of the crop is largely within the power of the planter, since by early planting of early maturing varieties the entire crop may be mature before the usual time of picking of the first cotton from native seed. Nevertheless, whatever modifications are necessary in different localities and during different seasons, they do not decrease the general strength of the recommendations.

The proper time for the destruction of the plants in the fall is whenever the weevils have become so numerous that there is no prospect that any more cotton will be made. It will be an easy matter for any planter to determine this point by an examination of a few plants in his field. Whenever it is found that all, or nearly all, of the squares and some of the bolls are being punctured, there is no hope for producing any more cotton. The farmer should then wait until the bolls already set on the plants have opened, and destruction should then take place immediately.

The rule should consequently be that the plants should be destroyed in the fall whenever all, or practically all, of the fruit is being damaged, regardless of whether this is in September or November. In the great majority of cases in Texas, from the 1st of October to the 15th of October would be the proper time. In many cases much earlier destruction could and should be practiced. Nevertheless, it should not be thought that fall destruction will be useless after the last date mentioned. Even up to the 15th of November many weevils in the remains of bolls hanging to the plants may be destroyed, but the process loses value the longer it is deferred. By all means, if possible, destruction of

plants should take place before frost, but destruction after frost, though not nearly as efficacious as earlier destruction, should always be practiced when it has not been possible to remove the plants previously.

METHOD OF REMOVING THE PLANTS.

The common practice of removing the cotton stalks from the fields by the use of the stalk cutter (a wheeled cylinder provided with oblique knives) is not effective in the fall destruction that should be practiced to avoid the damage by the boll weevil. The stalks remaining in that case during mild weather give rise to sprouts which furnish an abundance of food to weevils that would otherwise starve. Moreover, the fact that this machine cuts the stalks into short pieces makes the necessary collection of them difficult.

There are two effective methods of removing the plants from the ground. One of these, the method to be preferred, is to cut the roots 2 or 3 inches beneath the surface by the use of an ordinary plow or a lister. The other is to pull out the stalks by the use of a lever provided with a toothed notch which grasps the base of the plant. The latter process is better adapted for use when the plants have been killed by frost. When they are still green, or the ground is dry, it is frequently a difficult matter to remove them with these levers. The Department's general recommendation, therefore, is that the plants should be plowed out. As soon as possible after this is done, they should be collected by hand, or by means of rakes, and brought together in large heaps or windrows. It is very important that this collection should take place before the leaves have become dry and have dropped off. When the plants are carried to heaps immediately after uprooting, all of the leafage, which will dry in a few days, remains to facilitate the burning of the plants.

After the stalks have become dry enough, they should be burned. If the weather is fair, this could be done in about two weeks. If rains cause a lengthening of this period, it would undoubtedly be worth the cost to the planter to purchase crude oil sufficient to bring about the complete burning of all the stalks.

It is not considered necessary to leave any trap rows to attract such weevils as may have escaped the burning. The weevil seems to have but little tendency to be attracted to such plants. After the destruction of the main crop the spread would probably be in all directions and the numbers collected on the trap rows would consequently be inconsiderable. The time and expense of properly carrying on the hand picking of the weevils and infested fruit on trap rows would be a considerable handicap to the method on many plantations. Nevertheless, on small places where suitable labor is abundant, traps could conveniently be left. In such cases they should be situated on those sides of the fields which are generally leeward. They should be examined

daily for weevils and infested squares and bolls, which should be immersed in crude oil. After such collection for ten days, the trap plants should be uprooted and burned immediately with the aid of crude oil.

The suggestion has been made at various times that grazing the cotton fields with cattle is in some cases equivalent to destruction in the way that has been suggested. However, in many parts of Texas there are not sufficient cattle to accomplish the work, and, moreover, in very many fields the cattle, by disseminating Johnson grass and other plant pests, would undoubtedly do more harm than good. At the same time, the most thorough grazing always leaves a few green sprouts or leaves, upon which weevils may feed, and of course leaves the stalks standing, so that the process of leafing, for the benefit of the weevils, may continue indefinitely. Where the conditions of the fields allow it and the supply of cattle is sufficient, grazing the fields should be practiced, but it is not likely that this can generally be the case in Texas.

DIFFICULTIES.

The Department of Agriculture understands that there are some difficulties in the way of a universal following of the recommendations given in this circular. The principal ones are the almost universal hope for a top crop and in the labor conditions consequent from the universal tenant system of producing the staple. These difficulties are increased by the general scarcity of labor in the South, which is becoming more and more a serious problem in raising cotton.

Planters in infested localities must understand that with the presence of the weevil there is no longer any hope of a top crop. It is true that after considerable cotton has matured and after the plants have applied their energy to the formation of seeds and lint, fall rains often stimulate the production of a great number of squares. Many planters are misled by this into the hope of gathering a large top crop. The joints of the plant are short and the squares are formed rapidly and close together. Though weevils may have been exceedingly numerous in the fields, the presence of this abundance of food causes them to scatter and they are consequently temporarily somewhat less in evidence. In many cases blooms appear and the hope for a top crop increases. Nevertheless, this production of squares also contributes to the production of a large number of weevils late in the season and just at the time for their successful hibernation. As a result of this fact, great injury is done to the crop of the following season, with no gain whatever, or a very small one, in the yield of the current season. From these considerations it seems plain that within the weevil territory all hope of a top crop must be given up and the destruction of the plants be practiced as early in the fall as possible.

Another important difficulty lies in the tenant system. It is usually

the practice to terminate the work of the tenant with the picking of the cotton, leaving the clearing of the field for the next cropper. At present, after the cotton is picked the tenants frequently move to other plantations or to other parts of the same plantation. It should not be a difficult matter for planters to induce their tenants to practice the fall destruction of the plants as the last step in the production of a crop. In any case the plants have to be removed before the ground can be prepared for planting the following season; and the present recommendation merely involves applying, at a time some months earlier, the same amount of labor as is necessary in the spring. The best solution of the difficulty arising from the tenant system would be in the inclusion, in the agreement between the landlord and the tenant, of a provision which would bind the latter to clean the land thoroughly before leaving it.

In a comparatively small area in southwestern Texas it might be considered that there would be a further objection in the practice, which some farmers have, of encouraging the growth of volunteer or seppa cotton in the hope of procuring an early and inexpensive crop. As has been repeatedly pointed out by the Department of Agriculture, this is beyond question the worst possible practice in weevil-infested regions. The disastrous experience of several counties in the southern portion of the State during the present season has abundantly demonstrated the force of the warnings that have been issued from time to time. The staple produced by volunteer plants is short, kinky, and undesirable. Before the advent of the weevil, the only reason for encouraging such growth was to procure the first bale. Now, on account of its very detrimental bearing on the weevil problem, any attempt to raise cotton from volunteer cotton should by all means be discouraged.

The point may be raised that the burning of the plants in the fall removes valuable fertilizing constituents and that the continuance of the practice would seriously reduce the fertility of the soil. In reference to this matter, however, it must be stated that the present general practice is to clear the fields by burning the plants in the spring. Therefore, practically the only additional draft upon the soil by the method recommended is in the burning of many of the leaves and a portion of the roots. However, destruction of the plants can only take place after many of the leaves have fallen, and, in other cases, when the plants have become completely defoliated by the cotton caterpillar. The fertilizing constituents in various parts of the cotton plant have been carefully determined.¹ An estimate of the value of all the constituents which could possibly be removed by fall destruction, based upon the schedule of trade values adopted by experiment stations for

¹ See Bulletin 33 of the Office of Experiment Stations of this Department, pp. 81 to 142.

1898, shows that the loss per acre would be very small. It is plain that the planter could not only regain this small loss, but actually greatly increase the fertility of the land by the use of commercial fertilizers, which would cost an inconsiderable amount in comparison with the gain in the following crop, as a result of lessened damage by the boll weevil.

As a matter of fact, the preceding objections are not necessarily serious. They deal with general changes in cotton culture made necessary by the ravages of the boll weevil. As is beginning to be well known to Texas planters, it will not be possible for tenants to work as much land as formerly. More cotton will be produced by decreasing acreages and increasing the attention given to what remains. If this is done, the objections mentioned will largely disappear.

NECESSITY FOR A LAW.

The critical seriousness of the weevil problem, together with the demonstrated necessity of fall destruction, led to the recommendation, first made by Dr. L. O. Howard in Circular No. 14 of this Bureau, February 12, 1896, that some legal means of enforcement be provided by the legislatures of the States concerned. The recent work of the Department has all pointed towards the prime importance of this matter. Although there are no exact precedents for such a law, it is believed that its passage and enforcement would plainly be within the police powers of the State. It would not necessarily be essentially different in principle from the laws regarding the control of insects injurious to fruit trees, which are now in force in many States. Dr. Howard states: "The law should provide for the appointment of commissioners in each county. These commissioners should be empowered to enforce remedial work, to levy penalties, or to have the work done by their own agents, the cost to be assessed upon the property. It will be well to let this law have a wide bearing and not confine its application to this particular insect, but cover all injurious insects in case of future emergencies of a similar nature."

Mr. Jefferson Johnson, of Austin, Tex., whose extensive experience as a cotton planter and as chairman of the board of award under the Texas law appropriating a large sum as a reward for the discovery of a successful remedy for the boll weevil has made him thoroughly conversant with the habits of the pest, as well as with all means of controlling it which have been suggested, is firmly of the opinion that the time has come for the enactment of such a law.

From the present outlook, therefore, and as a result of extensive work with the boll weevil for several years, the Department of Agriculture warmly recommends the passage of laws regulating fall destruction of the cotton plants in the manner described in this circular in the States of Texas and Louisiana.

CONCLUSION.

Having studied and tested the methods of weevil control which have hitherto been recommended, the writer firmly believes that the destruction of the stalks in the early fall is the most effective method known of actually reducing the numbers of the pest. This destruction will cost but a small fraction of the expense necessary in the frequent picking up in the spring of the squares infested by the hibernated weevils, and is far more thorough as a means of reducing the numbers of the weevils than is the practice of picking hibernated weevils from the young plants. Early destruction of the stalks is essential to the greatest success of any system of controlling the pest. All other practices recommended, though very valuable in securing a crop, are of the greatest value as they are followed in connection with this one prime essential. Since the earliest investigations of the boll weevil made by this Department, it has been recognized that this practice is of the first importance, and the experience of recent years has added but certainty to this conviction. A number of planters have adopted it, and their work has abundantly demonstrated its efficiency. *It must not be thought that the procuring of the immediate crop is the only thing to be desired. Early and complete destruction of the stalks is undoubtedly the most important single element insuring success for the subsequent year.*

Concerted action in fall destruction is, of course, desirable. The greatest benefit will only result when whole communities adopt the method. But no planter should hesitate on account of the indifference of his neighbors. The fact that weevils move about but little until the time when the bulk of the crop is safe will assist materially in saving one field though nearby ones have not been properly treated, and, even under such circumstances, the success of the method in one field will be a powerful stimulus toward its general adoption the following season.

It is true that the recommendations contained in this circular involve considerable change in the practice of producing cotton. Nevertheless, the important changes that have been brought about up to this time in the use of improved seed and fertilizers have also been revolutionary in their character. It is hoped by the Department that the agencies that assisted in that matter—namely, organizations of business men—will everywhere devote the same energy towards encouraging the practice of what is, after all, the most important step in maintaining the supremacy of the cotton crop in the weevil regions.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., October 10, 1904.

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United States Department of Agriculture,
BUREAU OF ENTOMOLOGY.
L. O. HOWARD, Entomologist.

THE GREENHOUSE WHITE FLY.

(*Aleyrodes vaporariorum* Westw.)

By A. W. MORRILL,
Special Field Agent.

The damage by the greenhouse white fly to tomato, cucumber, and many other plants growing under glass easily places it in the front rank of greenhouse pests. In many cases it would be impossible to grow certain crops in forcing houses without the aid of remedial measures. A specific instance is on record where, in a western Massachusetts town, the attacks of this insect resulted in the total loss of a greenhouse crop of tomatoes and cucumbers valued at \$4,000.

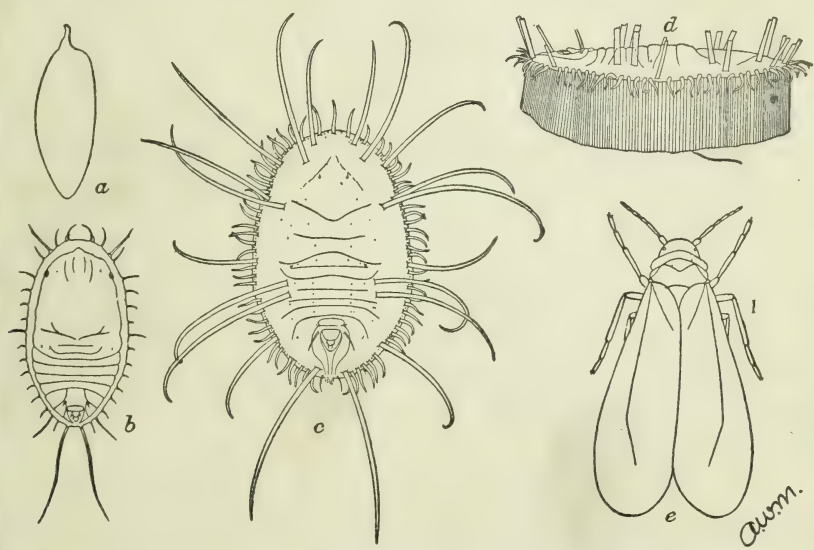


FIG. 1.—*Aleyrodes vaporariorum*: a, egg; b, young larva; c, pupa, top view; d, pupa, side view; e, adult—c, d, e, about 25 times natural size; a, b, still more enlarged (a-d, after Morrill, Tech. Bul. Mass. Exp. Sta.; e, original).

During the past few years many appeals for remedies have been made to the editors of our horticultural journals, to many State experiment stations, and to the United States Department of Agriculture; yet, although it is not, in reality, a difficult insect to control, the remedial methods which should be followed are far from being generally known among the many greenhouse men who suffer from its depredations.

HISTORY, ORIGIN, AND DISTRIBUTION.

The records of the greenhouse white fly date back to 1856,^a when Prof. W. O. Westwood, of England, recognized it as a previously undescribed species. The first published record, so far as is known to the writer, of the existence of the insect in this country was in the year 1870, when Dr. A. S. Packard, at that time Massachusetts State entomologist, reported it as occurring in abundance on tomato plants at Salem, Mass.^b

Two places have been suggested as the original home of this species, viz, Mexico and Brazil, but while presumably the origin is tropical American, there is no definite information on this point. Of more importance from a practical standpoint is its present distribution. Besides its occurrence in Europe, Canada, and Mexico, it is known to be widely distributed in greenhouses throughout the eastern United States, and without doubt it occurs more generally than the published records show. We have specific reports of its occurrence in greenhouses in the States of Maine, New Hampshire, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Illinois, Indiana, and Michigan, also in the District of Columbia.

FOOD PLANTS.

The insect under consideration is notable for its very general feeding habits, having already been recorded as breeding on over 60 different kinds of plants. Of these the following are of the most economic importance: Aster, chrysanthemum, salvia, lantana, fuchsia, coleus, ageratum, primula, geranium, heliotrope, rose, eggplant, bean, melon, lettuce, cucumber, and tomato. The two last named suffer the most serious injury from this insect, perhaps more than the other greenhouse plants together, although not infrequently there are reported serious losses in greenhouses devoted to one or more of the other plants mentioned.

DESCRIPTION AND LIFE HISTORY.

The mature white flies of both sexes are four-winged insects scarcely more than $1\frac{1}{2}$ mm. or three-fiftieths of an inch in length. The adult

^a Gardeners' Chronicle, p. 852.

^b Agriculture of Massachusetts for year 1870.

white flies, as well as the scale-like larvæ, are provided with sucking mouth parts. In a short time after the emergence of the adult from the pupa case, the body, legs, and wings become covered with a white, waxy substance which gives this, as well as other species of the genus, a characteristic floury appearance. The adults feed nearly continuously during their existence. If deprived of food, they will rarely live for a longer period than three days under ordinary temperature conditions. The longest recorded length of life of one of these insects in the adult condition is thirty-six days, but it seems probable that the average length of adult life is much greater than this instance would indicate. The largest number of eggs which an adult white fly is positively known to have deposited is 129, but this number is probably below the average. Indeed, the specimen which produced this number of eggs with little doubt deposited over 50 others which were not recorded. The number of eggs deposited per day by an adult female white fly in a laboratory has been found to average very nearly four. Probably in the warmer temperature of a greenhouse this number is greater by one or two eggs per day. These observations, even though falling short of showing the normal increase in numbers of this species, emphasize the importance of a remedy which will, above all, destroy the adults and check at once the rapid deposition of eggs. A peculiarity of the egg-laying habits of this and some other species of white fly is the tendency to deposit the eggs in a circle while feeding, using the beak as a pivot. These circles, when completed, are about $1\frac{1}{2}$ mm. in diameter and usually contain from 10 to 20 eggs each. On the more hairy leaves groups of eggs of this kind are less frequently met with than on those which are more nearly smooth. The majority of the adults are found upon the upper and newer leaves of the food plant. They are almost invariably found upon the underside of the leaves, and it is here that nearly all the eggs are deposited, although many are found upon the tender stems and leaf petioles and a very few scattering ones on the upper surfaces of the leaves.

The eggs are distinguishable with difficulty by the naked eye, being but one-fifth of a millimeter, or one one hundred and twenty-fifth of an inch, in length. They are more or less ovoid in form and suspended from the leaf by a short, slender stalk. With ordinary greenhouse temperatures the eggs hatch in from ten to twelve days. The newly hatched insect is flat, oval in outline, and provided with active legs and antennæ. It rarely crawls farther than one-half inch from the empty eggshell before settling down and inserting into the tissue of the leaf its thread-like beak. After feeding for five or six days, the insect is ready to molt its skin. The second and third stages are much alike, except in size, and differ principally from the first stage in that the legs and antennæ are vestigial and apparently functionless. These two stages occupy from four to six days each.

The so-called pupal stage, up to the time when growth ceases, is in reality the fourth larval stage, the fourth larval skin enveloping the true pupa. The pupæ and empty pupa skins are quite conspicuous when the insects are abundant. Their outline is similar to that of the larvæ, but they are thicker and box-like, about three-fourths of a millimeter, or three-hundredths of an inch, in length and provided with long, slender wax rods or secretions which are useful in distinguishing this from nearly allied species of the white fly.

The entire stage from the insect's third molt to the emergence of the adult form lasts from twelve to sixteen days in the laboratory and greenhouse. The adult emerges from a T-like opening, leaving the glistening white pupa case attached to the leaf. At first the wings of the adult are crumpled close to the body, giving them a peculiar appearance. In the course of a few hours the wings unfold and the insect has then completed its development, which has extended over nearly five weeks, if under the ordinary temperature conditions of a greenhouse.

CLOSELY RELATED FORMS.

In addition to the one here discussed, there are but two other species of white flies which are likely to be met with in the greenhouse. A white fly found infesting citrus plants would be likely to be the orange white fly (*Aleyrodes citri* Riley and Howard), while one infesting strawberry plants, either in the greenhouse or in the field, would probably prove to be the strawberry white fly (*Aleyrodes packardii* Morl.). The latter species resembles the one commonly found in greenhouses, but fortunately its list of food plants is much more restricted, it being apparently unable to subsist on the tomato.

APPEARANCE OF INFESTED PLANTS.

As already stated, the upper leaves of a plant are preferred by the adult females for the deposition of their eggs. Thus there is a slow but continuous migration of adults upward to keep pace with the unfolding of the leaf buds. On thoroughly infested plants we find on the uppermost leaves only adults and freshly laid eggs; a little lower on the plants we find eggs in the process of hatching; and, finally, on the lowermost parts of the plants we find discolored, shriveled leaves with many pupæ and emerging adults and few, if any, unhatched eggs or young larvæ. The larvæ and pupæ secrete little globules of honeydew, so named after the material of a like nature secreted by plant lice. These globules usually either drop or are forcibly ejected, and, falling on the upper surface of leaves directly below, give them a glazed appearance. This is frequently followed by the growth of a sooty fungus which hastens the complete destruction of the leaf.

When overcrowding of the young occurs, this fungus growth finds favorable conditions for its development on the under surface of the

leaf, resulting in the destruction of many of the immature insects. Owing to the interference with the respiratory processes of the leaf, both by the bodies of the insects themselves and by the fungus growths due to them, badly infested plants have a tendency to wilt when exposed to the sun's rays. In seriously infested greenhouses the leaves of the plants gradually die, the lower leaves first, and if unchecked the insects greatly impair the value and vitality of the plants, even though they do not actually cause their total destruction.

PREVENTIVES.

The importance of preventive measures in combating the white fly in greenhouses is not due to the inefficiency of properly applied remedies, but to the fact that in many cases the tiny depredator is unobserved until considerable injury has been accomplished. With little trouble and expense one may, in a large measure, preclude the possibility of this and other pests appearing in the winter in greenhouses which are unused during the summer months. The introduction of the insect into noninfested floral establishments may be prevented by avoiding the introduction of infested plants unless first subjecting them to a fumigation in a tight fumigating box, based on the directions hereafter given for entire greenhouses. Vegetable houses, which are not used during the summer months, allow of a practice which not only greatly reduces the chances of the white fly appearing in the house during the growing season, but may result in the house being successfully kept free from thrips and other insect pests during the whole or a considerable part of the season. The practice referred to consists in removing from the house all vegetation, even the smallest weeds, and fumigating the tightly closed greenhouse with hydrocyanic-acid gas at the rate of 5 or more ounces per thousand cubic feet of space for a ten hours' exposure.

REMEDIES.

Fumigation with hydrocyanic-acid gas.—This has been found to be the most successful means of controlling the white fly in greenhouses. Its success in this case is due to the susceptibility of the adults and larvæ of these insects to a comparatively long exposure to a small amount of the gas. Many experiments have been conducted with a view to determining the usefulness of this gas against the greenhouse white fly, the amount of gas to be generated, and the length of exposure necessary to produce the best results.^a Experiments of this kind thus far have been with tomato and cucumber plants, but as these plants are among those most liable to injury from improper fumigation with hydrocyanic-acid gas, a wide range of usefulness is indicated by the success thus far obtained.

^a Conn. Station Bul., No. 140; New Hampshire Station Bul., No. 100; Mass. Station Tech. Bul., No. 1; Maine Station Bul., No. 96; Can. Entomologist, XXXVI, p. 35; American Gardening, XIX, p. 741.

Amount of potassium cyanide to use and length of exposure.—Experiments and practice have shown that the white fly is destroyed in all except two stages (egg and late pupal) by an amount of potassium cyanide which is extremely small as compared with the amounts generally recommended for other insect pests. As small an amount as 0.005 gram^a per cubic foot of space, or between one-fifth and one-sixth ounce per 1,000 cubic feet, for three hours' exposure, has been used with success,^b while as large an amount as 1 ounce per 1,000 cubic feet for an "all-night exposure," in a house containing infested tomatoes, has been reported to have given, in one instance, a like result.^c On the other hand, Mr. E. C. Rittue, of the Bureau of Plant Industry of the Department of Agriculture, in attempting to control the white fly infesting tomatoes in a greenhouse on the grounds of the Department, found that 0.01 gram per cubic foot, or one-third ounce per 1,000 cubic feet, slightly injured the plants when the exposure exceeded thirty minutes. This treatment for thirty minutes destroys only the adults. The greenhouse is a new one and, judging from the great difference in the results obtained there and in other houses whose fumigation has been recorded in various publications, it is tighter and does not allow the gas to escape as readily as does the average forcing house.

This shows that the greatest difficulty attending the use of hydrocyanic-acid gas, in greenhouses containing plants as susceptible to injury by it as are the cucumber and tomato, is the difference in the tightness of different greenhouses. It is consequently impossible to give specific directions which will be suitable under all circumstances. A fumigation with hydrocyanic-acid gas which will kill adults only is not effective for practical use in checking the multiplication of the white flies. Rather than this, the method of control described under the heading, "Treatment when the use of hydrocyanic-acid gas is undesirable," is greatly to be preferred.

In most greenhouses, probably 0.007 gram of potassium cyanide for each cubic foot of space for an exposure not exceeding three hours represents the amount which will prove most effective for treatment of the insects without injury to tomato or cucumber plants. In many cases 0.01 gram per cubic foot has been found suitable for the same exposure, but this should not be used except in loose greenhouses where, after trial, a smaller amount is found ineffective. In all greenhouses when an attempt is to be made to control the white fly with hydrocyanic-acid gas, it is advisable to first use not more than 0.005 gram per cubic foot of space for a three hours' exposure. If this amount is sufficient for the house, none of the adults will recover after the fumigation, though in the course of two or three days many more

^a 28.35 grams=1 ounce.

^b Mass. Station Tech. Bul., No. 1, p. 46.

^c American Gardening, XIX, p. 741.

will emerge from the pupa cases. The larvæ, when destroyed, as they should be by the fumigation, change in two or three days from their normal glistening, greenish color to a yellowish or brownish color. When this result is not obtained by the first test, one or more further tests should be made, increasing the amount of potassium cyanide 0.001 gram per cubic foot of space for each test, with three days intervening to note results, until an amount is reached which is sufficient to destroy the larvæ, or until the tender leaves of the plant show injuries as a result of the fumigation.

Tests, thus far, with other greenhouse plants likely to be attacked by the white fly, according to available records, have all been for a much shorter exposure than three hours and with a much larger amount of potassium cyanide, but it is probable that in case plants other than the cucumber and tomato require treatment for this insect, preliminary tests in a fumigating box or in a small greenhouse will show that the amount of chemicals and length of exposure recommended for these two can be used without the slightest danger to other plants. In most cases much larger rates of potassium cyanide per cubic foot can be used.

Time to fumigate, preparation of greenhouse, and method of generating gas.—Fumigation of plants with hydrocyanic-acid gas should be at night and the foliage of the plants should be dry. The greenhouse to be treated should be made as tight as possible, all entrances but one closed and locked, and arrangements made to open a few ventilators from the outside at the expiration of the period of exposure. A house when fumigated should not be unnaturally tight as a result of rain or snow, otherwise the greater amount of gas confined in it under these conditions may injure the plants. The materials used for the generation of the gas are 98 per cent potassium cyanide, commercial sulphuric acid, and water, the proportions generally used being one-half more acid (liquid measure) than potassium cyanide, and one-half more water than acid. Having determined the cubic contents of the house and the total amount of potassium cyanide, sulphuric acid, and water to be used, these should be divided into parts representing each 25 feet of length of the greenhouse. Owing to the small amounts of the acid and water, small receptacles must be used. Six or 8 inches is a desirable height for the receptacles, while the diameter should be as small as possible to use, preferably not more than $2\frac{1}{2}$ inches. They should be either of earthenware or glass. In many cases, ordinary glass tumblers will be suitable, though the diluted acid should never more than one-fourth fill the receptacle; otherwise the violent chemical action which follows the introduction of the potassium cyanide might result in the loss of considerable of the material. Each lot of the potassium cyanide should be pulverized or broken up into small pieces, wrapped in thin paper, and laid beside one of the receptacles,

these being placed at intervals of about 25 feet on the floor of the house. In each receptacle first pour the proper amount of water and then the acid. Beginning with the end of the house farthest from the exit, drop into each receptacle, in succession, the package of potassium cyanide, proceeding as quickly as possible toward the exit. During the few seconds the operator is in the house after the generation of the gas is started, the breath should be held to prevent even the least bad effects. Close and lock the door of the house and, after three hours, partially ventilate it by opening the ventilators, previously arranged for opening from the outside. One ventilator for every 25 or 30 feet, opened for ten or fifteen minutes, is sufficient to protect the plants from possible bad effects of overexposure to the gas. Before inhaling air in the house, however, the ventilation should be more thorough, so that no odor of the gas, which is much like that of peach pits, can be detected. The morning after the fumigation the contents of the receptacles should be buried.

Time for subsequent fumigations.—A single fumigation, according to the directions given above, will destroy practically all of the insects except the eggs and some of those in the late pupal stage. Although one such treatment might check the insects so that they would not cause noticeable damage for weeks, in many cases it would be the part of economy to give two more fumigations at times which a knowledge of the life history of the white fly indicates would be most advantageous. Knowing that the egg and late pupal stage of the insect are not to any great extent affected by the treatment recommended, while all the other stages may be destroyed, and knowing the duration of each stage, we can outline a plan of treatment which will practically eradicate the pest in the worst-infested greenhouses. Two subsequent fumigations two and four weeks, respectively, after the first will subject to the gas all of the white flies in the house in stages wherein, under ordinary circumstances, they are unable to withstand its destructive effects.

Treatment when the use of hydrocyanic-acid gas is undesirable.—Fumigation with tobacco fumes, made by burning the refuse stems and leaves, has no effect on the greenhouse white fly beyond temporarily stupefying the adults. The adults may be destroyed, however, by vaporizing in the infested house certain tobacco extracts which are sold in liquid form. To accomplish this result preliminary tests should be made, first using the amount recommended in the directions accompanying the preparation. The attempt to control the greenhouse white fly by means of tobacco extracts alone has never, to the writer's knowledge, proven successful, while many cases of failure have been reported. The frequent fumigation necessary to control the insect when once it has become abundant would be impractical and costly. However, in connection with syringing the plants with a

soap solution such a treatment may sometimes be of value, although only when the use of hydrocyanic-acid gas is impossible or for some reason undesirable.

Among the sprays, the best brands of whale-oil soap, used in the proportion of 1 to $1\frac{1}{2}$ ounces per gallon of water, have been found to destroy all of the white flies except the eggs, a small percentage of the nearly mature pupæ, and from 25 to 50 per cent of the adults which escape the spray by flying from the plants. It is not advisable to syringe tomato plants in greenhouses at any time, when avoidable, as syringing interferes with pollination and produces a damp atmosphere which promotes rot, but the injury by syringing may be as nothing compared with that which is caused daily by the insects. When the use of hydrocyanic-acid gas is impractical, an all-night fumigation with a tobacco extract is recommended, followed during the next day by a syringing with a solution of whale-oil soap or its equivalent.

Comparative cost of the treatment.—Potassium cyanide costs from about 30 to 50 cents per pound, according to the amount purchased. Commercial sulphuric acid costs from about $2\frac{1}{2}$ to 10 cents per pound. The entire cost for a single fumigation of a greenhouse containing 20,000 cubic feet is between 20 and 30 cents. The labor required is scarcely, if any, greater than for fumigation with other materials. A single fumigation with a suitable tobacco extract would cost, in a house of the same size, at least \$1.50, and the cost of labor for the syringing which is recommended to follow such fumigation would probably not be less than \$1. The soap required would cost only a few cents, though possibly as much as the materials used in a fumigation with hydrocyanic-acid gas.

CAUTIONS.

Hydrocyanic-acid gas is one of the deadliest poisons known, and should always be handled with the greatest care. Never hold the potassium cyanide in the bare hand when pulverizing, but wrap up the lumps in two or more thicknesses of cloth before breaking with a hammer. Dust or small pieces of potassium cyanide should not be thrown away in exposed places, but always buried, as should the contents of the receptacles of the chemicals after the fumigation. Never inhale air in a greenhouse after the generation of gas has begun, and provide against anyone entering the house before it is properly ventilated.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *February 15, 1905.*

CIRCULAR No. 58.

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist.

REPORT ON THE GYPSY MOTH AND THE BROWN-TAIL MOTH,
JULY, 1904.

By C. L. MARLATT,

In charge of Experimental Field Work.

The renewal, in the summer of 1904, of excessive damage by the gypsy moth in the woodlands about Boston, and more or less in the residential districts, was brought to the attention of the Secretary of Agriculture primarily by Congressman Ernest W. Roberts, of Chelsea (Boston), and about the same time, also, by the secretary of the Massachusetts State board of agriculture, Mr. J. Lewis Ellsworth, in a letter addressed to the Entomologist of the Department. In compliance with the request of Mr. Roberts, the Secretary of Agriculture authorized a thorough investigation of the present status of the gypsy moth in Massachusetts, and, at the same time, of the brown-tail moth. Acting under instructions from the Entomologist, Dr. L. O. Howard, the writer spent some three weeks (July 1-22) in going over the infested districts about Boston, and visiting certain localities in adjoining States. The conditions found, relative to the two pests named, are summarized below.

THE GYPSY MOTH.

(Porthetria dispar Linn.)

The work of the gypsy moth committee terminated in January, 1900. The condition of the infested district about Boston at that time, as shown by the reports of the committee, and by careful examinations made by the Entomologist, Doctor Howard, and also, a little prior to the termination of the work, by the writer, was most satisfactory, from the standpoint of control, at least. In other words,

the very efficient and careful work of the agents of the committee had exterminated the moth in many of the restricted outer colonies, reduced it to inconsiderable numbers in others, and prevented defoliation in the more generally infested districts. The policy of the committee had been to effect extermination, as fast as possible, in the outer portions of the infested region, working gradually inward, but at the same time keeping up sufficient work in the central districts to prevent any material injury.

In the prosecution of this work the committee had apparently good reason to believe that extermination had been effected in a great many isolated colonies, including a considerable number of large and important ones, and it was believed by them that with sufficient funds actual extermination of the insect over the entire region of infestation would ultimately be accomplished. Whether this was possible or not, at least it had been demonstrated that the gypsy moth could be exterminated in isolated colonies, and reduced to inconsiderable numbers, or to a status approaching extermination, in areas of more general infestation.

With the cessation of the operations of the gypsy moth committee under State appropriation, the gypsy moth was left to multiply and spread at will, save for work undertaken here and there by individuals, and, in the residential districts, by the local authorities of many of the infested towns, the latter work being usually under the charge either of tree wardens or of street commissioners. In the case of the Fells reservation, also, a good deal of work has been done, especially during the last two years, under the general direction of Mr. B. de las Casas, chairman of the Metropolitan Park Commission, by Mr. Charles F. Price, in charge of the reservation. Other large areas of forest infestation, such as those surrounding the Lynn woods, and many private estates, have gone practically untreated. In the residential districts of some towns very good work has been done, as noted, by individuals or the town officials; and, while the gypsy moth has not been exterminated in these districts, it has been kept down, so that no marked defoliation of street and yard trees has resulted.

The amount expended during the last two years in such work of control, judging from careful inquiry and estimate, probably almost equals the amount expended by the State during the years of its most active operations against the gypsy moth, namely, approaching \$200,000. A single individual, Gen. S. C. Lawrence, has, for the last three years, had a large force of men working on certain gypsy moth colonies in his own and adjoining forest lands, expending each year, as he assures the writer, more than the actual value of the lands. Hundreds of individuals in each town have expended sums ranging

from \$10 to \$100 in the control of the gypsy and brown-tail moths. Nearly every town corporation has made expenditures of from a few hundred dollars to several thousand dollars for the same purpose. A number of experts, or foresters, have gone into the business of clearing the premises of individuals of gypsy and brown-tail moths, and find constant employment for considerable forces of men. In general this work is excellently done. The chief difficulty, however, is that this and other work against the moths is scattering or patchy; in other words, while some take good care of their property, others give no attention to theirs, thus leaving numerous spots for the unchecked multiplication of the pests. The result is, that while practically as much money is now being expended as was formerly spent by the State, the results are by no means comparable, from lack of general direction and uniformity.

As a consequence of the general reduction in the number of gypsy moths at the close of the work by the State, for the first two years very little notable damage was exhibited in either the woodlands or the residential districts. In September, 1902, the writer made a rather careful survey of the worst gypsy-moth regions, in company with Mr. A. H. Kirkland, former entomologist of the gypsy moth committee. At this time very little damage in the way of actual stripping of considerable areas of woodland was to be seen. A few comparatively small areas of actually-defoliated woodland were found, and the general presence of the moth was noted in the central residential districts always worst infested, but even here there was very little actual stripping. There was ample evidence, however, that the moth was on the increase, and promise of considerable damage in the immediate future. The comparatively little injury in the woodlands in 1902 was a matter of surprise, and the suggestion was made by Mr. Kirkland that this had probably resulted from the attack of birds and other natural enemies. The greater scarcity of such natural means of control in the residential districts was suggested as the explanation for the greater infestation here noted.

The conditions found in 1902 scarcely prepared the writer for the status shown in the course of the investigations just completed. During the years 1903-4 the gypsy moth had evidently made extraordinary progress, and a condition of infestation and defoliation or stripping was found which the writer had never before seen in the gypsy-moth region, and which was undoubtedly many times greater than in the worst of the earlier years of gypsy-moth damage.

In company with Mr. A. H. Kirkland, as assistant and guide, the writer made a thorough investigation of substantially all of the regions about Boston known to have been infested by the gypsy moth in 1900, and of certain new colonies which have been discovered since that time. On one occasion we were accompanied by the gypsy moth

committee of the Massachusetts State board of agriculture, General Lawrence, Professor Fernald, and others, in a tour of inspection throughout the worst districts in Medford, Malden, Melrose, and the Middlesex Fells reservation. Another day we were accompanied by Congressman Roberts and local officials from several of the worst infested towns, and also by Mr. Las Casas and Superintendent Price of the Fells reservation. In various towns we received assistance and guidance from the local tree wardens and street commissioners, and notably, in Newton, from Mr. C. W. Ross, street commissioner. On four days Mr. Kirkland and the writer were accompanied by Mr. H. L. Frost, a forester who has been doing excellent work in the control of the gypsy and brown-tail moths in Arlington and other towns. A map (fig. 1) of the infested areas was prepared and accompanies this report.

The present area infested by the gypsy moth, as shown by the careful examinations made, is substantially the same as at the close of the work by the State of Massachusetts. There has, in other words, apparently been very little extension in the area infested. Some important new colonies were discovered, but these were within the general limits of the old range of the insect. The failure of the gypsy moth to widely extend its range during the four years since 1900 is largely due to the fact, already noted, that at the close of State operations against this insect it had been reduced to such inconsiderable numbers that it was not until the present summer (1904), or perhaps to a less extent in the summer of 1903, that it had gained sufficient headway to furnish favorable conditions for distribution and the establishment of new colonies. Its excessive multiplication in the summer of 1904 will very probably lead to considerable extension of its range, and many new colonies will undoubtedly be started this year (1905).

The area of worst infestation, where general stripping of forests has resulted, extends in a broad avenue from Arlington and Winchester, or more properly from the western border of the Mystic Lakes, across Medford, including the southern edge of the Fells reservation, a portion of Melrose, and the upper half of Malden, and continues eastward through Saugus to the Saugus River. In this region the forests and the street trees are, as a rule, very generally defoliated and as bare as in winter, and altogether several thousands of acres of completely defoliated woodland occur in this strip. Spots of stripping ranging from 50 to several hundred acres, as indicated on the map by the cross-hatched areas, were found in Winchester, Lexington, Woburn, northern Melrose, and Saugus; and there were also considerable areas bounding the northern side of the Lynn woods, a single large colony in the center of the Lynn woods just above

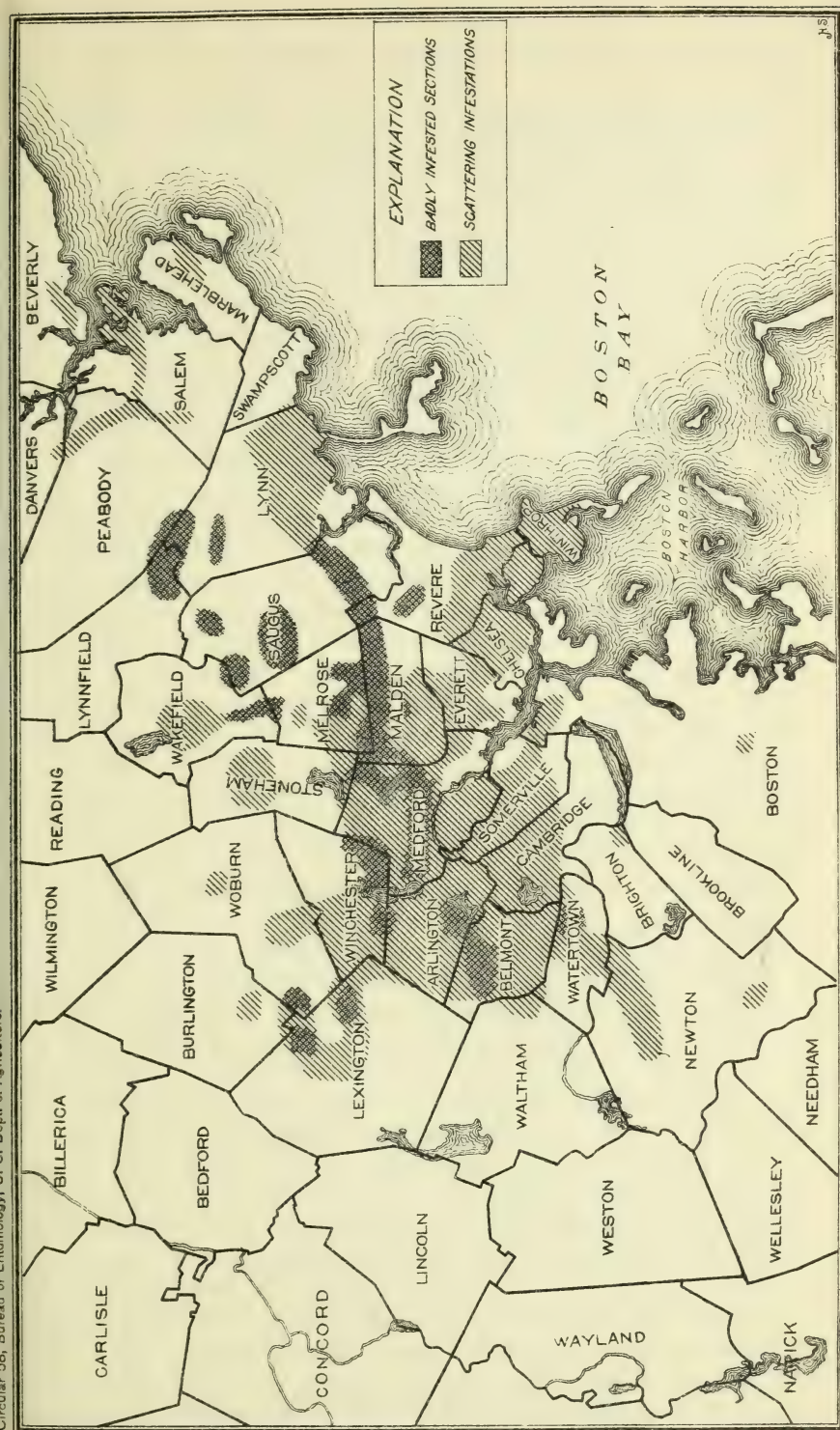


FIG. 1.—MAP OF BOSTON DISTRICT SHOWING TERRITORY INFESTED BY THE GYPSY MOTHS IN 1904.

Valden Pond, and areas in Revere, Belmont, Watertown, and western Cambridge.

Scattering infestation, that is, the occasional or fairly general occurrence of the larvæ of the gypsy moth, without, however, resulting in complete or notable stripping of the street trees and forests, was found through much of the southern half of the Fells reservation, and practically throughout the towns lying within the area of worst infestation indicated, and as far south as the Charles River. Exterior to this area of general infestation, scattering presence of the gypsy moth was found in Lexington, Winchester, and Woburn to the north-west; in Stoneham, Wakefield, Saugus, and Reading to the north; and in Peabody, Salem, Beverly, Marblehead, and Lynn to the north-east. To the west, Arlington, Belmont, Watertown, and Cambridge west of Harvard Square are much infested. In Newton there are perhaps some twenty-five small points of infestation, as reported by the street commissioner, Mr. Ross. Very good work in the way of control has been done in this town, and with the exception of the new colony located near Newton post-office, on the Van Etten estate, only scattering larvæ were found. The colony just referred to was discovered last year (1903), and represents a spot of bad infestation, covering a considerable area of garden, orchard, and ornamental plants. In the southern portion of Newton is located one of the worst of the outer colonies found during the course of the work of the gypsy moth committee. This colony, near the intersection of Dedham and Parker streets, originally covered several hundred acres of woodland, and was made the subject of very thorough extermination work by the committee. This work has since been followed up to some extent under the direction of Mr. Ross. A careful examination of this area shows much of it still free from the gypsy moth, but occasionally larvæ were found, showing that there is still a scattering infestation here and there which in a few years will be sufficient to repeat the damage of 1896, when the colony was first located. No larvæ were found in 1902 or 1903 in the area covered by this colony, and the insect is evidently, therefore, just beginning to get a new start. In South Boston the gypsy moth has increased very little, and the extermination of several of the worst colonies seems to have been effected. This is true of the Dorchester colony (Sargent street), where a considerable residential area, including also some forested hillsides which were badly infested in 1898, shows now no examples of the insect. The infestation still exists in the residential district at West Cottage street, Dorchester. In the old colonies examined at Brookline no larvæ or other indications of infestation were found.

One of the most interesting features of the investigation was the demonstration that in a good many areas the careful work of the gypsy moth committee has resulted in the extermination of the insect.

This is due entirely to the work of the committee in some instances, and in others, where the work of the committee was only of one or two years' duration, the insect had evidently been reduced to such inconsiderable numbers that the natural enemies had completed the work of extermination. This is notably the case in the Georgetown colony, which had only one year's work. Other bad colonies in which the gypsy moth has not reappeared are Mount Gilead colony in Lynn woods, the colonies at Spring Pond, Peabody, Cedar Hill in Swampscott, Sargent street in South Boston, the Overlook colony in Franklin Park, and a considerable colony in the extreme western portion of the district in the town of Lincoln, the Schlesinger colony in Brookline, and a good many other less important points of infestation. Several of the areas in which the gypsy moth committee reported the moth as exterminated, and which now show slight infestation, may have become reinfested from other districts in the intervening years. The exterminated colonies enumerated, and the general control shown at the close of the work of the gypsy moth committee, indicate with sufficient emphasis that intelligent and efficient work against the gypsy moth will prevent any material damage to woodlands or residential districts.

This discussion of the gypsy moth has related entirely to the infestation about Boston. Numerous reports of infestation at remote points, and occasionally in the adjacent States, have been received by the gypsy moth committee, and by others interested in this insect. All of these reports, with the exception of one, have proven to be misidentifications, other insects having been mistaken for the gypsy moth. Most of these reports are based on the occurrence of the brown-tail moth, which has a much wider range, and which is very commonly confused with the gypsy moth in the popular mind. While the writer was conducting these investigations about Boston a very persistent and apparently well-authenticated report came to his attention of the occurrence of a well-established colony of the gypsy moth at Nashua, N. H. A visit to this town demonstrated that this, like most of the others, was an instance of confusion of the gypsy moth with the brown-tail moth, the insect at Nashua proving to be the latter species. In Massachusetts the most remote authentic point of infestation was in East Bridgewater. The writer visited this point and found that the insect had been actually introduced here, possibly maliciously, or possibly accidentally, but had been thoroughly exterminated. The infestation was limited to an isolated apple tree growing in the angle of a dwelling house, and was discovered in 1902. It proved to be a comparatively easy matter to thoroughly eradicate the pest here, and there was no evidence of work this year.

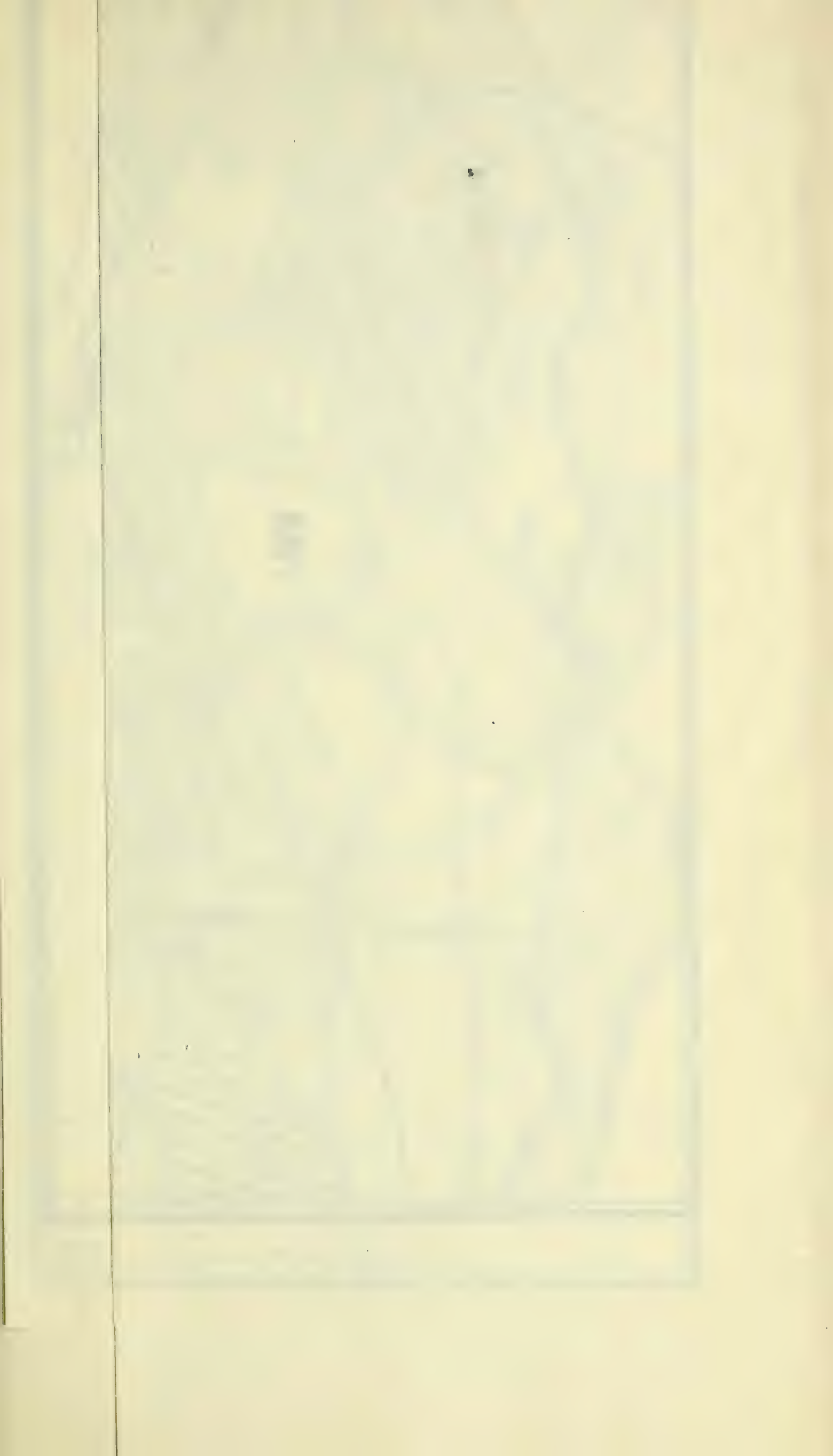
The point of infestation referred to outside of the region about Boston is in the city of Providence, R. I. This infestation has been made the subject of a special report by the Rhode Island State board of agriculture, namely, Bulletin No. 13, published September, 1901, by the late James M. Southwick, curator of the Roger Williams Park Museum. The discovery of the presence of this insect in Providence was made in July, 1901, and was investigated thoroughly at the time by Mr. Southwick, with the assistance of Prof. A. H. Kirkland, who was called down from Boston. When discovered the gypsy moth was confined to the west side of Providence, where it was established in a half dozen or more distinct colonies. The occurrence of these distinct centers of infestation, all of apparently the same age, in the heart of the city, leads to the suspicion that the insect may have been maliciously colonized at these separate points. It is impossible to believe that these distinct colonies should have been accidentally started in Providence at the same time, especially in view of the difficulties in the way of the transportation of the gypsy moth and its very slow spread about Boston, as indicated by its history during the last thirty-six years. The infestation in Providence illustrates one of the great dangers from the gypsy moth. It is readily spread by carrying egg masses, and maliciously-inclined individuals can thus easily start new colonies at any distance from the present infested area. In view of this, as emphasized by the Providence infestation, it is highly desirable that heavy penalties be provided for any malicious colonization of the gypsy moth. The important points of infestation in Providence are indicated on the accompanying map (fig. 2). The writer was assisted in locating their exact position by Messrs. Joseph D. Fitts, supervisor of parks, Providence, and C. A. Davis, present curator of the Roger Williams Park Museum. At the present time these colonies are still in existence, in spite of local work done in the way of control. Notable stripping has not occurred this year, but the larvæ and pupæ were easily discovered at the points of infestation, and there is, therefore, opportunity for much increase in the future and a repetition of the experience about Boston.

MEANS OF CONTROL.

The work of the gypsy moth committee of the State of Massachusetts developed a number of means of controlling the moth of the highest practical value and efficiency, and nothing can now be suggested in the way of improvement on these methods. The general adoption and enforcement of these will undoubtedly keep the gypsy moth in substantial control, so that no material damage to woodlands or to shade trees in residential districts need be feared. In the case of small properties, or where but a few trees are to be protected, these

means of control can be employed effectively and at reasonable cost by the individual owner. This is true, also, of the shade trees in residential districts, coming under the supervision of the street commissioners or other local officers. Where, however, large areas of woodlands are badly infested, the cost of control is beyond any reasonable expenditure by individual owners. As already indicated, such control, for a year or two at least, may much exceed in cost the actual value of the land, rendering it prohibitive so far as the individual is concerned. Furthermore, in the case of individual holdings, without any means of enforcement or corrective work, many will take little interest in the gypsy moth, and therefore do nothing to prevent its local increase, thus nullifying the work of others. In the case of large public domains, also, as, for example, the Middlesex Fells reservation, the cost of control is beyond any reasonable portion of the appropriation for the maintenance of such reservations which might be set aside for work against the gypsy moth.

If the gypsy moth is to be effectively controlled, it will be necessary to have concerted action over the entire infested area, and this will necessitate a central authority and direction. There is a wide diversity of opinion as to the best method of carrying on such work. The plan employed by the gypsy moth committee consisted in expending a lump appropriation by the State in control or extermination of colonies throughout the infested district, the State appropriation covering all of the expense, none of which, therefore, was charged to the town or individual benefited. This system has some advantages. It has, however, the objection that it does not give any incentive for local control, or the protection of property by the individual. It therefore seems to the writer preferable to devise some system in which the cost of control would be divided between the individual owner, the town, and the State or National Government, should national aid be granted. This idea is not altogether original, but has been given somewhat in this form by various persons who have given thought to the subject. It has been suggested that the individual whose premises were found to be infested should be charged with a portion of the cost of the extermination not to exceed the taxes on the infested property, the cost of control above this amount to be divided in accordance with some determined ratio between the town and State. The advantage of this system is simply that it keeps up, in the individual and town, a wholesome interest in the control of the pest, and in many cases the individual will take some trouble to keep his premises clean, and the town, likewise, will institute care of the streets and parks, while under the old system little or no individual or local effort will be made to prevent infestation or to stamp out the gypsy moth. The damage now being done by the gypsy moth is so widespread and so severe that some general system of control must be provided for at



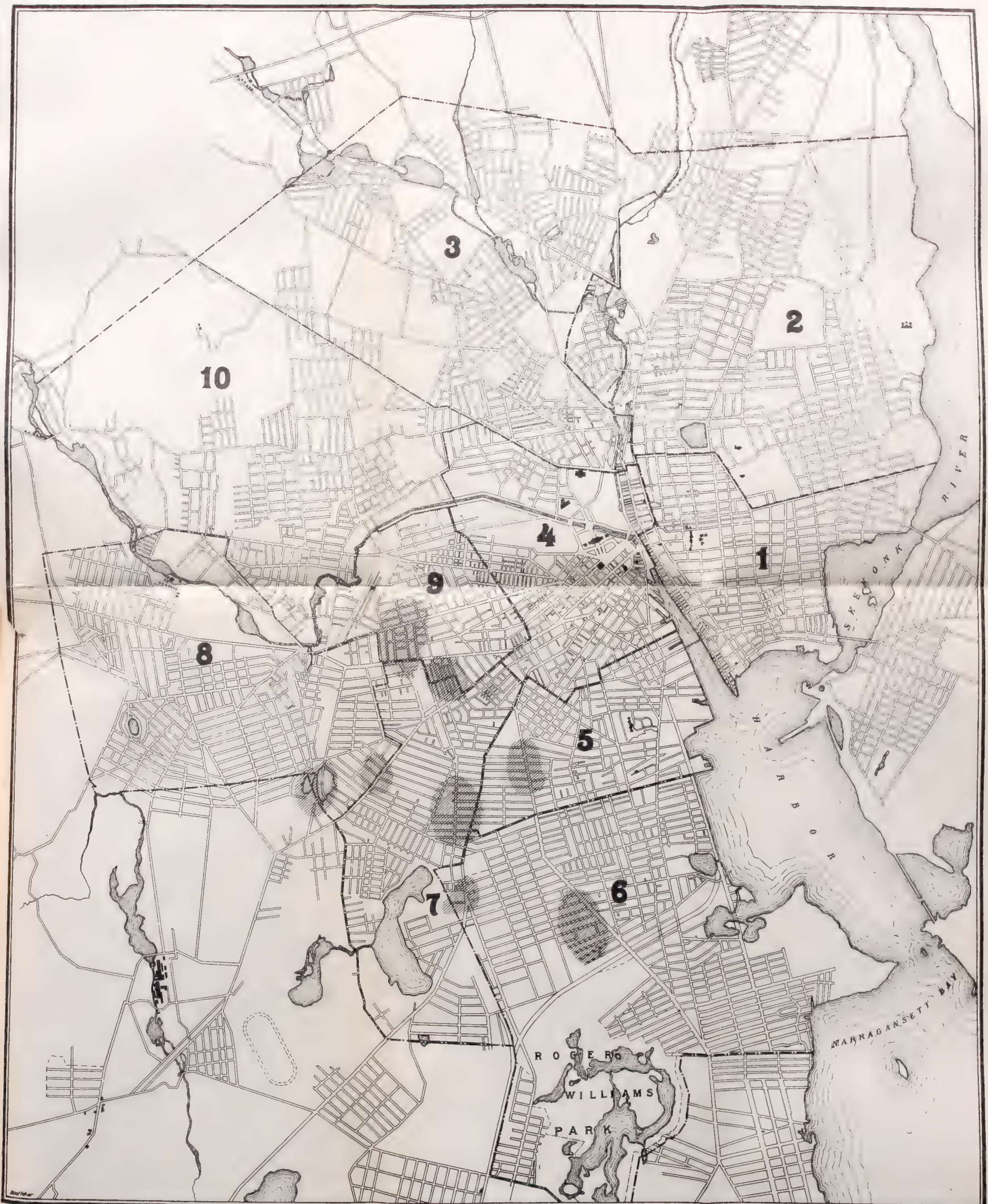


FIG. 2—POINTS OF GYPSY-MOTH INFESTATION IN PROVIDENCE, RHODE ISLAND.

once if the beauty of the forest and residential districts about Boston is to be maintained. The cost of control will undoubtedly be less, under efficient general direction by some central authority, than the patchy and more or less intermittent work now being done.

The fact should not be lost sight of that control of the gypsy moth will be a continuous charge on the State, towns, and individuals. In other words, this insect has now reached a stage when extermination is practically impossible. The cost of control will vastly decrease, however, once the present excessive infestation is overcome. A large expenditure for two or three years must be expected; after which a much smaller sum will be sufficient to locate any important colonies which may develop, and effect their substantial extermination. The cost of protection in residential districts and on private properties of small area should, in a few years, be reduced to almost nothing, if good work be done for two or three seasons over the whole area. The outlook, therefore, is not necessarily a serious one. Such control, furthermore, will very largely check the wider distribution of the gypsy moth, and substantial protection will thus be afforded to the State of Massachusetts and adjoining States. Even left to itself the moth spreads very slowly, as shown by the rather limited area now infested after over thirty years of the presence of the pest about Boston. The danger from natural spread, therefore, to the State at large and to the adjoining States is small. A slow spread must necessarily be expected, but with efficient control it will be many years before it widely extends its range in Massachusetts.

Another important step which may be taken looking to the control of this pest is the introduction of its natural enemies from Europe and Asia. As long as the operations of the gypsy moth committee were conducted solely to the end of extermination, it was not especially necessary to introduce natural enemies. For the successful introduction of these it would have been necessary to have kept undisturbed large colonies of caterpillars in which the foreign parasites and predaceous enemies could multiply. With the object of extermination in view this was distinctly undesirable, but now that extermination is out of the question it becomes desirable and feasible to make the effort to introduce such natural enemies and to leave undisturbed isolated colonies of the moth in woodland districts in which these experiments can be conducted. It is well known that in Europe and Asia, the original home of the gypsy moth, the pest is not often very destructive. Bad colonies will occasionally appear, only to disappear again in a year or two. This disappearance and the general inactivity of the moth in its native home are doubtless very largely due to the efficiency of parasitic and predaceous insect enemies. From the studies of European entomologists and foresters, such natural enemies are well known. The introduction of these into Massachusetts would

not be attended with any possible risk, as the insects introduced feed solely on the larvæ of the gypsy moth and other allied pests, and in the absence of such food themselves perish. If national aid is to be granted to the State of Massachusetts in its warfare against this pest, such aid might very properly be in the direction of securing, importing, and installing such natural enemies. It should not be lost sight of, however, that any work of this character is purely experimental, and its value to be determined only after an interval of four or five years or more. It would probably take at least two summers in Europe to make effective importations of the parasites, and two or three more years would be necessary for their large multiplication in the gypsy-moth colonies about Boston. Furthermore, such importation might in the end prove not to be especially valuable as a means in the control of the pest. Therefore, during such experimental work the control of the pest by standard means should be kept up over the entire area infested with the exception of the particular spots of infestation, or colonies set aside for experiment with natural enemies.

THE BROWN-TAIL MOTH.

(*Euproctis chrysorrhœa* Linn.)

The brown-tail moth is now even better known about Boston than is the gypsy moth. The widespread information relative to the brown-tail moth arises chiefly from the fact that the hairs of the larvæ are distinctly poisonous and nettling, and thousands of people throughout the range of this pest have been poisoned the present summer or during past years. The hairs produce on sensitive subjects (and very few are entirely immune) a rash or nettling, with some festering, which lasts for a week or more, and is attended with more or less itching and irritation. This poisoning may result from the falling of the caterpillar on the neck and hands or clothing of the passer-by, or from the loosened hairs shed from the cast larval skin at the time of transformation to the chrysalis stage.

The loosened hairs, or the shed skin, are blown about by the winds and frequently attach to clothing hung up in yards for drying. By this means they are conveyed to the skin, resulting often in very general inflammation.

In addition to its very distinct importance as a source of discomfort to human beings, the brown-tail moth is an important tree pest, and is common in orchards in Europe. It was accidentally introduced into Somerville (Boston) and was brought to the attention of the gypsy moth committee in the spring of 1897. The investigations conducted at the time by the gypsy moth committee led to the belief that it was introduced by a floral establishment, which had been importing roses from Holland and France previous to 1890. It seems probable

that this pest was introduced on this stock, and, escaping into near-by pear orchards, had gained considerable local spread before it was noticed.

A general account of this insect has been published by the gypsy moth committee, and it has lately been made the subject of a special volume by Prof. Charles H. Fernald, of Amherst, assisted by Mr. A. H. Kirkland. The larvæ of the brown-tail moth feed by preference on the foliage of fruit trees, especially pear and apple. The chief damage, therefore, in this direction has been in orchards or on fruit trees grown in yards. It has, however, a wide range of food plants, and will subsist on many forest trees, although notable damage or forest stripping has not been characteristic of it. The habits of the insect render it much more readily controlled than the gypsy moth. The winter is passed in the half-grown larval stage in small but conspicuous webs attached to the terminal twigs. The chief means of control is the collection in the winter of these webs and burning them, and, if this be done with any degree of thoroughness, trouble from the brown-tail moth may be very largely overcome.

Unlike the gypsy moth, the female of the brown-tail moth is a strong flyer, and hence the distribution of this insect has been very rapid. It has now overrun southern New Hampshire and southwestern Maine, as well as the northeastern counties of Massachusetts, and will undoubtedly extend its range widely in North America in a comparatively few years. There is no means of preventing such ultimate spread, but prompt effort at control will much retard its progress. During July, 1904, while the writer was conducting his investigations about Boston, the moths of this insect were emerging in great numbers, and were attracted in their nocturnal flight to electric and other lights. It was no uncommon sight to see electric-light poles whitened by hundreds of these snowy white moths, and thousands were killed about the electric lights. Some benefit could undoubtedly be obtained by a trap connected to electric lights which would destroy more of the moths than the lights do themselves.

During the time when the flight of these moths was at its height enormous numbers of them were brought by favoring winds into the heart of Boston, causing considerable interest and excitement in Newspaper Row, the swarm having centered there, and resulted in a number of accounts, illustrated by photographs locally taken, in the daily papers of the following morning.

The distribution of the brown-tail moth, as already indicated, has been in a northerly direction. South of Boston it is known to occur in the double tier of towns bordering Massachusetts Bay as far as Scituate. The entire northeastern portion of Massachusetts was invaded as early as 1899. By 1902 the invasion had extended westward to Brockton, Hudson, and Stow, in Massachusetts. The moth

was reported at Kittery, Me., as early as 1899, by the late Prof. F. L. Harvey. It has also been reported by Prof. James Fletcher, the Canadian Government entomologist, as occurring at St. Johns, New Brunswick, where it was supposed to have been transported by steamers plying between Boston and St. Johns. In 1902 the moth was abundant in all the towns along the eastern division of the Boston and Maine Railroad, as far as Portsmouth, N. H. During the last two years, and especially the summer of 1904, the moth must have extended its ravages considerably in both New Hampshire and Maine. Its occurrence at Nashua, N. H., has been referred to in the discussion of the gypsy moth. The counties of Rockingham, Hillsboro, and Stafford, N. H., are known to be pretty generally infested.

Strong gales of wind at night during the flying season must extend the distribution of this moth many miles. This was illustrated by the results of the high gales prevailing in New England July 12-14, 1897, which were largely responsible for the spread of the moth over much of the area now infested. The ability of this moth to extend its range over much of northeastern United States in the near future is abundantly shown by this instance and its history up to the present time.

The control of this moth will need, perhaps, less of town and State aid than the gypsy moth, but some provision should be made to enforce the removal of the caterpillars' webs in winter, and the authorities charged with the work against the gypsy moth should be empowered to enforce corrective work against the brown-tail moth also. In the introduction of parasites for the gypsy moth the brown-tail moth should also be considered. These two insects have many common natural enemies, but the special enemies of each should be introduced. For detailed information on the history of the brown-tail moth and on means of control, reference is made to the publications cited above.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., March 21, 1905.

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist.

THE CORN ROOT-WORMS.

By F. H. CHITTENDEN,

In Charge of Breeding Experiments.

Among the many enemies of Indian corn two forms of slender, soft-bodied, whitish larvæ known as root-worms are prominent through their injuries. When the plants are found to be withering or when the ears fail to fully develop, forming "nubbins," without any visible cause, the earth about the roots should be searched. It then frequently happens that root-worms are found at work. They operate somewhat in the manner of wireworms, and the two forms vary somewhat in the nature of their operations, as well as in the territory which they ravage. They are the young of two species of leaf-beetles of the family Chrysomelidæ and of the tribe Galerucini.

The species which inhabits the middle western region is the western or northern corn root-worm (*Diabrotica longicornis* Say). Its injuries are practically confined to the middle West, where it would be a very serious pest were it not that progressive farmers in that region have adopted as a part of a sound agricultural routine a system of rotation which greatly reduces losses that might otherwise be sustained.¹ In spite, however, of the best methods of tillage, losses due to this insect are reckoned in millions of dollars annually. Thus Prof. F. M. Webster estimated the damage accomplished by this pest to corn in 24 counties of Indiana alone in 1885 at nearly \$2,000,000, this judgment being based on a loss of \$16,000 sustained by one farmer and a personal knowledge of the destructive abundance of the insect throughout that State.

The second species is the Southern corn root-worm (*Diabrotica 12-punctata* Ol). It occurs generally throughout nearly the whole of the United States, but fortunately its injurious range is somewhat closely restricted to the southern States, though in recent years it is showing a disposition to extend depredations into more northern regions.

The former species attacks first the fibrous roots and later the larger ones which it frequently destroys to such an extent that the infested plants may easily be pulled up by hand after they are seen to wither. The latter, at least in the maturing stage, eats directly into the stalk at a point near the upper whorl of roots. If injury by either species is not extensive, the ears, as previously stated, do not entirely develop.

¹For more detailed information see Forbes, 18th Rept. St. Ent. Ill., 1891-92 (1894, pp. 146-165); Bul. 44, Univ. Ill., May, 1896, pp. 282-296; Webster, Ind. Agl. Rept., 1885, author's ed., pp. 6-10; Riley, Insect Life, Vol. IV, pp. 104-108.

THE SOUTHERN CORN ROOT-WORM.

(Diabrotica 12-punctata Ol.)

This species is also known in the South as the "bud-worm" and less commonly as the "drill worm." In some regions it is recognized only by the former name, while the latter is of more recent use. The beetle is familiar to most persons in its occurrence on cucumber, squash, and other cucurbits. It frequents the flowers, and by peeping into them one or more beetles and the places where they have gnawed the petals may be seen, for they are among the most omnivorous of insects and appear to be able to subsist on any form of vegetation on which they may happen to alight. They are, in fact, to be found in practically all fields of corn and in gardens everywhere, but it is seldom that the larvæ

are associated with the beetles except by those well versed in entomology or who have had experience with both forms of insects. The species is best known northward as the twelve-spotted cucumber beetle.

DESCRIPTIVE.

This insect has four stages, adult or beetle, egg, larva, and pupa.

The beetle is elongate pyriform, yellowish green in color, and the

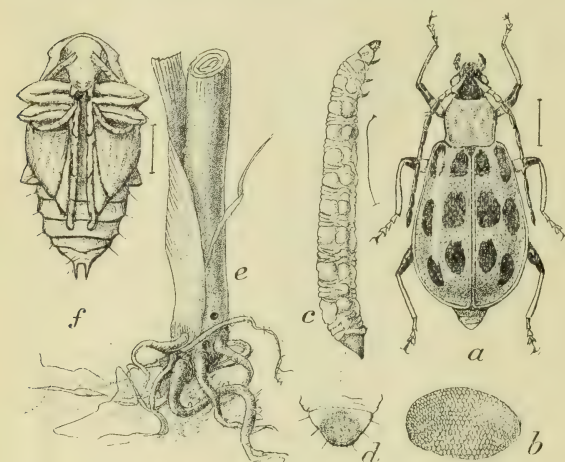


FIG. 1.—Southern corn root-worm (*Diabrotica 12-punctata*): *a*, beetle; *b*, egg; *c*, larva; *d*, anal segment of larva; *e*, work of larva at base of cornstalk; *f*, pupa—all much enlarged except *e*, which is reduced (reengraved after Riley, except *f*, after Chittenden).

elytra or wing-covers are marked with twelve black spots (fig. 1, *a*). The head is black, as are also the legs, except portions of the femora or thighs. The length is one-fourth of an inch or a little longer.

The egg (*b*) does not differ materially from that of related species, such as the striped cucumber beetle, except in size. It is broadly oval in shape, measuring in the average 0.025 inch in length. The color is dull yellow, and the surface is closely and somewhat regularly faceted.

The larva (*c*) is slender, even thread-like, delicate and soft-bodied, and white or yellowish in color. The body is smooth and cylindrical, the head short and rounded, and brownish in color, and the first thoracic segment is also slightly brown, while the anterior extremity as a rule ends in two points.¹

¹ Less acute than in the striped cucumber beetle (*Diabrotica vittata*) and sometimes obtuse or wanting.

The above characters, with the aid of the illustrations (fig. 1, *c*, *d*), serve to distinguish this corn root-worm from young wireworms¹ with which they are often associated in injury to corn and other cereals, grasses, and other plants. Before changing to pupa this root-worm attains a length of about half an inch.

The pupa (fig. 1, *f*) presents no special features worthy of remark that are not shown in the accompanying illustration. It is white like the larva, and similar to that of the striped cucumber beetle.

GEOGRAPHICAL DISTRIBUTION.

The twelve-spotted cucumber beetle occurs commonly throughout that portion of the United States lying between the Atlantic seacoast and the base of the Rocky Mountains, and from New England to Florida. It also inhabits Canada in the North and extends in a southwesterly direction through Texas into Mexico. Throughout practically all this region, which includes portions of twenty-nine States, it is really abundant, though not nearly so destructive in the northern as in the southern States, where year by year more or less injury is accomplished by the larvæ or root-worms as far northward as Maryland, Virginia, and southern Ohio.²

FOOD HABITS.

The adult, as stated, is practically omnivorous. Its known food materials are legion and include, besides the blades, green ears, silk, and pollen of corn, the partly matured kernels of wheat, corn, and oats, the foliage of alfalfa, corn, clover, crimson clover, cotton, rye, tobacco, beets, cabbage, kale, cauliflower, turnip, mustard, cucumber, cantaloupe, watermelon, pumpkin, squash, okra, potato, tomato, rhubarb, and asparagus, the leaves and pods of beans, as also the buds, flowers, and sometimes the leaves of fruit trees, including apple, pear, quince, apricot, cherry, and peach, the buds and flowers of roses, dahlia, sunflower, aster, canna, chrysanthemum, grapevine, sweet pea, cosmos, cultivated *Bidens*, and raspberry, the fruit of apple, melons and other cucurbits. To all of these more or less serious injury is inflicted. Among wild plants, or such as are of little practical utility, frequented by the beetles for food are golden-rod (*Solidago*), wild sunflower, New Jersey tea (*Ceanothus*), pokeweed (*Phytolacca*), milkweed (*Asclepias*), groundsel (*Senecio*), horse nettle, *Nelumbo*, *Impatiens*, and *Amorpha*.³

¹ The latter, it should be stated, are usually more or less flattened, especially at the head, while the posterior extremity is usually toothed, notched, or pointed. They also serve to separate this root-worm from maggots of several small flies, such as the seed-corn maggots, which also infest corn roots. The root-feeding maggots, however, are footless, while the root-worms have six legs placed near the head.

² In the Pacific States it is replaced by a similar very closely related species, *Diabrotica soror* Lec., which is sometimes quite injurious.

³ Some of the food plants above enumerated have not hitherto been recorded.

Larvæ or pupæ have been observed at the roots of corn, wheat, rye, millet (*Panicum miliaceum* and *Bromus unioloides*), beans, Rudbeckia, and sedges of the genera *Cyperus* and *Scirpus*. The favorite larval food plants are evidently Gramineæ, including various cereals and grasses, and the Cyperaceæ or sedges.¹

The presence of this root-worm in a field of corn gives origin to the loss of the roots, injury varying according to the age of the corn and the severity of attack, and somewhat also upon the condition of the weather and of the soil infested. Injury is manifested in various ways, from the death of a plant to slight retardation in its growth or what is sometimes termed "spindling," or a yellowish and unhealthy look. In plants 6 inches or less in height the perforations of the stalk (fig. 1, *c*) are characteristic, and usually show just below the surface of the ground. This is accompanied by withering of the plant, which is frequently killed outright. It is this appearance which has given the insect the name of "bud-worm." Quite frequently plants are destroyed almost as soon as sprouted. As plants grow, the signs of injury vary according to the degree of development. If plants suspected of harboring this species are pulled up and shaken over a sheet of cloth or paper, the root-worms can be dislodged, and it is not difficult to distinguish them from any other forms of insects to be found in the same locations, with the exception of the western corn root-worm, which, however, seldom occurs in the same regions.

LIFE HISTORY.

This beetle is one of the earliest as well as latest species. About the District of Columbia the beetles have been seen abroad by the last week in March, and eggs have been obtained from April 18 to May 9. Beetles have been seen freely feeding until the middle of November, when the flowers which had furnished them with food began to wilt and die. Just when the first new generation appears seems not to have been recorded, but several beetles, still immature, have been seen in the open by the writer on June 12, others were reared the same day and in July, and still others were seen, newly transformed, late in September. Although the writer can not speak with positiveness as yet as to the number of generations, these indications show the probable production of two and perhaps three generations annually in the District of Columbia, and there is the possibility of four in the insect's more southern range.

Eggs are laid, as has been stated, at the base of the insect's food plant, and have been observed by the writer to hatch in six and seven days in cool May weather. One individual deposited 202 eggs.

¹ Larvæ have been found and reared by the writer from about the roots of Jamestown weed (*Datura*) and pigweed (*Amaranthus*), and it is not improbable that they feed on these plants.

NATURAL ENEMIES.

The beetle is parasitized by a Tachina fly, *Celatoria diabroticæ* Shimer (fig 2), which develops in the abdomen of its host. It is preyed upon by the wheel bug, *Arilus (Prionidus) cristatus* Linn., and many birds feed to a considerable extent on the beetles. It is also subject to a bacterial disease.¹

REMEDIES.

For the root-worm the use of insecticides on growing corn is impracticable. In fact, we can not reach the root-worm stage to any extent with poisons. Therefore we must have recourse to farming methods. Injury in corn fields is most abundant when the seed has been planted in bottom lands, and if planting is necessary in such locations, it should be done late, in Georgia by the first of May, according to Quaintance; or attack may be so distributed that damage will be inconsequential by dropping eight or ten grains of seed corn in each hill. Of still more importance, however, is judicious crop rotation. Numbers of crops are not injured to any extent by the Southern corn root-worm, and of these are cotton, buckwheat, the smaller grains, and various garden vegetables other than beans and cucurbits. Experience will teach which of these can best be employed as alternates. It is inadvisable to plant squash and pumpkin to any extent in rows between the hills of corn, more particularly in regions where injury by this species has been previously observed.



FIG. 2.—*Celatoria diabroticæ*, fly parasite of corn root-worm beetle—much enlarged (original).

For the beetle as it occurs on cucumber, squash, and other cucurbits the same remedies in use against the striped cucumber beetle should be pursued.² In its occurrence on most other crops it can be controlled in the same manner as other leaf-beetles, for example, the Colorado potato beetle, by applying an arsenical alone or combined with Bordeaux mixture, the latter having a repellent effect. Arsenate of lead is preferable to Paris green as it adheres to the foliage better and is not washed off so readily by rains, and there is little or no danger of scorching.

There is little that can be done to lessen the number of beetles for ensuing years, because of their roving habits and their ability to subsist on such a vast variety of vegetation. The species appears to have no particular food material, if we except flowers of cucurbits, goldenrod, and some others, and thus the beetles are seldom found congregated where they could be destroyed "at wholesale."

¹ Forbes, 17th Rept. St. Ent. Ill., 1889 and 1890 (1891), pp. 71-73.

² See Circular 31, entitled "The Striped Cucumber Beetle (*Diabrotica vittata* Fab.)."

THE WESTERN CORN ROOT-WORM.

(Diabrotica longicornis Say.)

DESCRIPTIVE.

The beetle may be readily distinguished from its Southern congener by its nearly uniform pale, but usually distinctly grass-green, or greenish yellow color. (Preserved specimens usually lose this coloration to a considerable extent.) It is also smaller, of about the same size as the striped cucumber beetle, measuring about a fifth, or a little more, of an inch in length, and is a little more slender and less pear-shaped (fig. 3, *a*). In the earlier stage the Western corn root-worm very closely resembles the Southern species, all stages naturally being smaller, as would be expected in an insect of smaller size.

The egg. This applies particularly to the egg, which is of similar form and sculpture. It has only about 20 hexagonal pits in its longest diameter, compared with 30 to 35 in that of its congener. It is, moreover, dirty white instead of yellowish, and measures only .015 to .025 inch as against .02 to .03 in the Southern species.

The larva, when fully mature, attains a length of only four-tenths of an inch as compared with half an inch in the case of the Southern form.

In other respects they are very similar, as will be noted by comparison of the illustration of the Western species (fig. 3, *b*) with the Southern (fig. 1, *c*). The anal segment in the larva under consideration is always blunt, never armed with tuberculous points.

The pupa (fig. 3, *d*), judging from available material, though smaller, is proportionately wider, giving it a more robust appearance than in the Southern species.

DISTRIBUTION.

This species, which was first recognized as a pest in 1874, has a more limited geographical range than the preceding, and is moreover confined in its field of destructiveness. We know of its occurrence from central New York and Canada, including Nova Scotia, westward to Kansas and Nebraska. Injurious occurrences are limited to the States of Illinois, where it is most troublesome, Indiana, Iowa, Kansas, Nebraska, Ohio, and Missouri. It does not occur in destructive numbers in Kentucky; in fact it is rarely found in that State. It was very injurious in the vicinity of Chillicothe, Ohio, in 1903, and injuries were reported at Circleville,

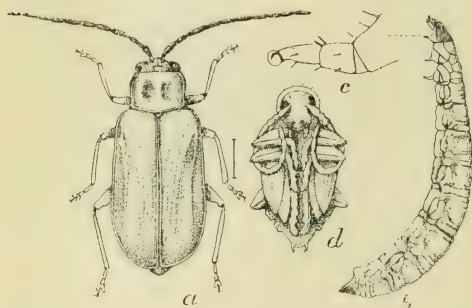


FIG. 3.—Western corn root-worm (*Diabrotica longicornis*): *a*, beetle; *b*, larva or root-worm; *c*, enlarged leg of same—all enlarged, *d*, more enlarged (original.)

just south of Columbus, Ohio, the same year. Reports from southern Ohio in 1904 indicate that the species is increasing in abundance in that region.

FOOD AND OTHER HABITS.

It has already been stated that corn is the only known host plant of the larva. The beetles show a disposition to feed on a variety of plants, but are more choice than the southern species. In the experience of the writer and evidently of others also, the beetles, which are naturally pollen feeders, like other members of this genus, are partial to the blossoms of thistle (in which they deeply imbed themselves), sunflower, and goldenrod, and are less frequently found on cucurbits. It is probable that the beetles do some damage to corn by eating the pollen and gnawing the silk and tassels, thus preventing cross-fertilization and causing a partial blasting of ears. Other plants, also, are frequented for the sake of pollen, and the list includes ragweed and smartweed growing between hills of corn, clover, and some other plants. In late fall the beetles have the same habit as the twelve-spotted and striped cucumber beetles, of gnawing into ripe squash and pumpkin in the field, and they do some injury in this way. The plants attacked include bean, sorghum, and cotton, which are visited for pollen, and ripe apples, which are sometimes injured in the same manner as cucurbits; and the beetles have been noticed gnawing the ears of corn, more particularly where they have first been injured by birds or grasshoppers. Since the beetles have been observed by Forbes to feed on fungi, blights, rusts, etc., there is no doubt that they do some harm, which has been positively ascertained to be the case with the striped cucumber beetle, in acting as conveyors of fungous diseases from unhealthy to vigorous plants.

The species is credited with being single-brooded. The beetles occur normally in the field, like the Southern species, until November, subsisting upon such flowers and other vegetation as can be obtained at that time, and in open winters have been noted abroad as late as the middle of December, which is, in the writer's opinion, proof positive that the beetles hibernate, but the observations of Messrs. Forbes and Webster indicate that as a rule the species passes the winter in the egg condition, in the earth. If this hypothesis is true it differs from the great majority of leaf-beetles. Eggs, so far as known, are deposited in fields of corn late in the season and hatch the following spring. Larvæ have been seen in central Illinois the second week in June, and the beetles have been reported in southeastern Iowa toward the end of June. Forbes assigns the first weeks of August and October as the average times for the first and last deposit of the eggs, and recognizes a period of eight or nine weeks for the passage of a generation from the first to the last stage. The egg-hatching period is set from the middle of May to the middle of July and a little later.

Eggs are deposited in the earth in more or less scattered clusters of three to ten, and at a depth varying from 1 to 6 inches, all being placed about the roots in a space a few inches around each hill.

The developing larvæ live entirely beneath the surface, feeding on the roots, which they mine either upward or downward, and seem capable of traveling from one root to another. Pupation also takes place underground, and pupæ may be found in considerable numbers, at the proper period, about infested corn roots. When the beetles begin to issue, toward the latter part of August, they are first noticeably abundant on thistle blossoms, and afterward on other plants blooming at this season. Like the twelve-spotted cucumber beetle, they show a disposition, late in the season, to disperse before seeking quarters for hibernation or the deposit of their eggs, flying from one field to another.

PREVENTION AND REMEDY.

This species is more readily controlled than the Southern corn root-worm ; in fact, losses can be prevented by simply following crop rotation. Since the insect, as far as observed, feeds in its larval condition only on corn, the planting of infested land to any other crop leads to the starvation of the young when they hatch in the spring. This is no mere inference, but has been tested time and again. In Illinois, according to Forbes, it is ordinarily safe to plant corn two years in succession, but it is unwise to plant it again without an alternate. It is also imprudent to plant corn in fields or meadows in which the beetle has been observed in great abundance on clover and certain weeds in late October the previous year.

One other measure is to be recommended, as a general farm practice. It consists in the maintenance of the fertility of the soil by the use of manures and other fertilizers. Although this does not diminish attack, it sometimes enables the plants to withstand injury.

Approved :

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *March 23, 1905.*

CIRCULAR NO. 60.

United States Department of Agriculture, BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist.

THE IMPORTED CABBAGE WORM.

(*Pontia rapæ* Linn.)

By F. H. CHITTENDEN,

In Charge of Breeding Experiments.

GENERAL CHARACTERISTICS.

The worst of the many destructive enemies of cabbage and other crucifers is the larva or caterpillar of a white butterfly known to science as *Pontia* (*Pieris*) *rapæ* Linn. The caterpillar, called the imported cabbage worm, is altogether too well known by farmers throughout this country as well as in the Old World, and the adult in sect, the imported cabbage butterfly, called also the white or rape butterfly, is a familiar object to nearly everyone. It is generally recognized that the butterfly is the parent of the "worms."

This cabbage worm is velvety green in color, much like the cabbage on which it feeds; and the surface of the body, if viewed through an ordinary hand lens, is seen to be somewhat rough and finely dotted with small black spots. There is a faint yellow stripe down the middle of the back and a row of yellow spots along each side in line with the spiracles or breathing pores. It measures, when full-grown, about an inch and a fourth, presenting the appearance shown in figure 1, *c*.

The butterfly has a wing expanse of nearly two inches, and is white, marked with black near the tips of the fore-wings, as shown at figure 1, *a*, representing the female. In this sex there are two conspicuous black spots on each fore-wing; the male (fig. 2) has only one. Both

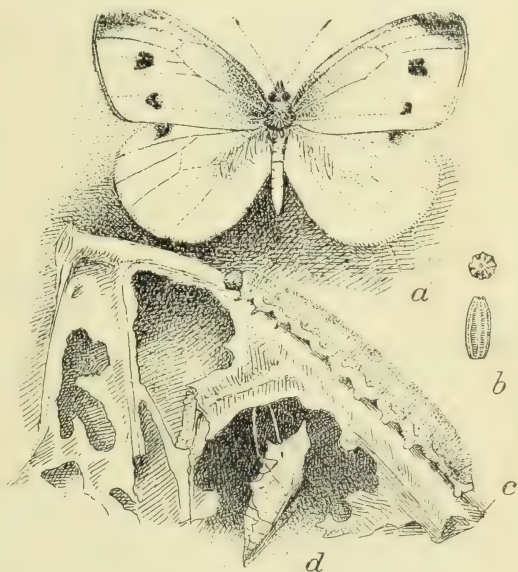


FIG. 1.—*Pontia rapæ*: *a*, female butterfly; *b*, above, egg as seen from above; below, egg as seen from side; *c*, larva in natural position on cabbage leaf; *d*, suspended chrysalis—*a*, *c*, *d*, slightly enlarged; *b*, more enlarged (original).

sexes have a corresponding smaller black spot at the upper extremity of the hind-wings. The body of the female is whitish; that of the male is usually darker above. The male is generally a little the smaller. The under surface of the hind-wings are uniform satiny straw-yellow and there are generally two black spots showing through, in both sexes.

The eggs are fusiform, pale yellowish, and strongly ribbed (fig. 1, *b*). They are large enough to be readily seen with the unaided eye, and are deposited singly, usually on the lower surface of the outer leaves of cabbage and other food plants.

When the caterpillar or "worm" becomes full grown it attaches itself to a cabbage leaf or other nearby object, fastens itself by means of a string-like girdle, and often within the same day transforms to a chrysa-

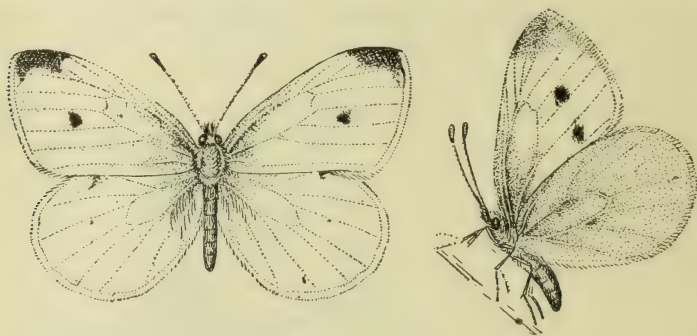


FIG. 2.—Imported cabbage butterfly: male, wings expanded, at left; wings folded in natural resting position at right—somewhat enlarged (original).

lis of the appearance indicated at figure 1, *d*. The chrysalis is of variable color, seeming to be influenced in this respect by the object upon which it is placed. The color thus varies from dirty gray to yellow, green, and dark gray. The length of the chrysalis is a little less than three-fourths of an inch.

NATURE OF INJURY.

This cabbage worm has been rightly termed the bane of the cabbage-grower, and the dread of every careful cook and housewife. It begins work early in the season, and the principal damage is therefore usually to young plants. After riddling the outer leaves, which continue afterward attached to the stalk, it attacks the more tender inner leaves as they form, frequently secreting itself in the heads, which are made most unsightly by its dark green excrement, and where it is difficult to reach with insecticides. As a result, cabbages before being sent to market must be carefully examined and the damaged leaves plucked away; and before cooking it is frequently necessary to tear the heads apart to see that no disgusting "worm" is lurking within. Even after the dish is cooked there is danger of an admixture of animal with the vegetable food. In cool weather the caterpillar frequently feeds in free exposure on the upper surface of the leaves in the sunshine.

As early as 1869, when this cabbage worm was restricted to limited areas in Canada, New England, and New York, it did great damage. At St. Albans Bay, Vt., in that year it caused the total destruction of a crop of 3,000 cabbage plants. The worms made their appearance about the first of September, and there were from 10 to 50 on a head. The Abbé Provancher estimated the same year a loss of \$240,000 in the vicinity of Quebec alone. One farmer near Montreal lost in a single season over 12,000 heads of cabbage. The following year, according to Mr. Angus, the entire crop of cabbage and cauliflower in some places about New York City, where the insects had appeared only the year before, was destroyed. The loss was estimated at half a million dollars.

An interesting feature connected with the establishment of this insect in America is the practical extirpation, at least as a pest, of the so-called southern cabbage butterfly (*Pontia protodice* Bois.¹) in many regions. This is accounted for in part by the earlier spring appearance of the imported species, enabling the caterpillars to obtain possession of the best feeding places and crowd out the less hardy native form.²

ORIGIN AND DISTRIBUTION.

The imported cabbage butterfly was introduced from Europe perhaps half a century before the date of present writing,³ and was first recognized from a capture at Quebec, Canada, in 1860. It was not again seen until two years later, in the same locality. For several years after this it was observed at intervals in other portions of Canada. In 1865 its first appearance in the United States was noticed in Maine. The following year it was seen in northern New Hampshire and Vermont. By 1868 it had reached New York, and a few years later began to attract attention, as each year thereafter it was found in some new locality. In 1875 it appeared in Cleveland, Ohio, and two years later in Illinois. By 1880 it had penetrated southward to the Gulf region. This distribution has continued until now the species is known practically in every State and Territory of the Union, although it is occasionally reported as new to some more or less isolated locality.

It does not appear to be an inhabitant of any particular life zone, seeming to be as much of a pest in the Gulf States as in Canada and New England.

In the Eastern Hemisphere this butterfly ranges from the Atlantic to

¹ This native species and the imported cabbage butterfly are very generally referred to in literature as *Pieris protodice* and *P. rapæ* respectively.

² It is well known that nearly all species introduced from the Eastern Hemisphere are more hardy than native American forms and survive conditions which would be unfavorable to the latter. In the writer's experience, the southern cabbage butterfly is more susceptible to disease than the imported species. Occasionally the latter returns in moderate numbers to localities from which it has apparently been absent for long periods.

³ Riley believed it was introduced in 1856 or 1857 (see Rept. Dept. Agr. for 1883, p. 108). A monographic account of this species is given by Scudder (Butterflies Eastern U. S. and Can., Vol. II, pp. 1171-1190, 1205-1218).

the Pacific, in most localities between the thirtieth and sixtieth degrees of latitude. In Switzerland it occurs on the level of perpetual snow, and in this country it has been taken on the barren subalpine heights of the White Mountains.

FOOD AND OTHER HABITS.

The imported cabbage worm feeds on the foliage of nearly all cruciferous plants, is particularly fond of cabbage and cauliflower, and somewhat less destructive to turnip, radish, mustard, and horseradish. It also does considerable injury to ornamental plants, such as nasturtium, mignonette, sweet alyssum, and spider plant (*Cleome*).¹

The butterflies sip the nectar of flowers of many kinds, and are to be seen any time hovering over them. They are especially fond of the white blossoms of crucifers, also of such plants as white aster, lavender, and thistle. Like other butterflies, this species is diurnal, and is on the wing from early morning until near dusk. It is a comparatively slow flyer, but capable of extended flight for long distances. The butterflies sometimes congregate in immense swarms, as has frequently occurred where the insect has emigrated from the continent of Europe to England. Its occurrence in mid-ocean has been recorded.

LIFE HISTORY.

The butterflies appear as early as March, even in the Northern States, and thereafter can usually be seen flying about cabbage fields and elsewhere, throughout the year, until after several severe frosts in October. In the Gulf States they occur throughout the season.

Egg deposit commences soon after the butterflies appear; in fact, pairing and egg-laying may begin within a day or two after the adult issues from the chrysalis. The duration of the different stages varies according to temperature. The observed egg period is from four to eight days.

The larva eats voraciously and grows with great rapidity, attaining full maturity in from ten days to two week after hatching. It molts four times; hence there are five distinct stages, the first molt taking place (in warm weather) in about two days from the hour of hatching, the second stage lasting two or three days; the third and fourth, one or two days each, and the fifth, four or five days². The duration of the chrysalis stage is from seven days to a fortnight during the summer time, but the last chrysalides formed in the more northern States remain undeveloped during the winter until the following spring.

The life cycle occupies periods varying between twenty-two days and five weeks. Even in New England this species is credited with being triple-brooded, but in the District of Columbia and vicinity there

¹ It is a decided pest on this plant in the District of Columbia.

² Technical descriptions of the different larval stages with particular reference to wing development are given by W. F. Mercer (*Jour. N. Y. Ent. Soc.*, Vol. VIII, pp. 1-20, March, 1900).

must be one or more additional generations, and there is a possibility of at least six in the extreme South. The first generation develops on wild plants.

NATURAL ENEMIES.

Were it not for certain natural checks this species would be a still greater pest than it is. The most important of its insect enemies are small parasites, all introductions from Europe. One of them, a Bra-

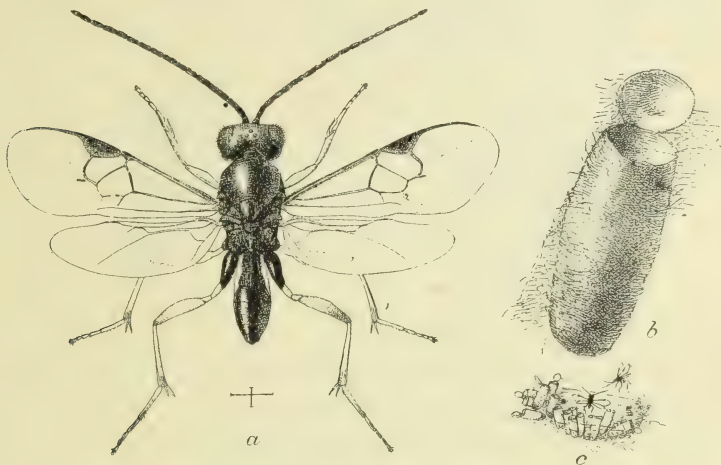


FIG. 3.—*Apanteles glomeratus*: a, adult fly; b, cocoon; c, flies escaping from cocoons—
a, b, highly magnified; c, natural size (original).

conid, *Apanteles glomeratus* Linn. (fig. 3), was purposely imported in 1883 from England. During the autumn of 1904 this species held its

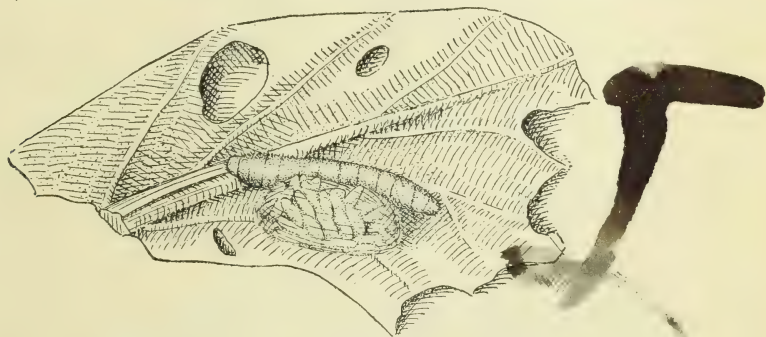


FIG. 4.—Parasitized cabbage worm (*Pontia rapae*), showing cocoon mass
of *Apanteles glomeratus* below (original).

host under complete control at Washington, D. C., killing every "worm" which came under the writer's observation. A larva which has been destroyed by this parasite is shown in figure 4, together with the parasite's cocoons. A secondary parasite, a minute chalcid fly, *Tetrastichus microgastri* Bouché, was also present, but did not militate against the effectiveness of the *Apanteles*. Of similar importance to

this *Apanteles* is a chalcis fly, *Pteromalus puparum* Linn. (fig. 5), noticed in this country in 1869, having evidently been imported with its host.

Wasps, particularly *Polistes pallipes* Lepel., and related forms are also of great service in reducing the numbers of this and other cabbage worms, appearing to prefer them to other prey.

A small, evil-smelling plant-bug, *Phymata wolffii* Stål. (fig. 6), secretes itself in flowers, such as thistle and goldenrod, and destroys numbers of the butterflies, capturing them and sucking out their vital fluids.



FIG. 5.—*Pteromalus puparum*: female at left; male at right—highly magnified (original).

Numerous other enemies attack this cabbage worm in addition to the ones that have been enumerated,¹ and it is sometimes subject to a con-



FIG. 6.—*Phymata wolffii*: a, dorsal view; b, lateral view; c, front leg; d, snout—*a, b*, enlarged; *c, d*, more enlarged (from Riley).

tagious bacterial disease² similar to that of the cabbage looper.³ It is, however, less susceptible to this malady, and is seldom destroyed in any numbers by it. The parasitic flies can be encouraged by collecting the larvæ and chrysalides of the cabbage butterfly and placing them in barrels or boxes covered

with coarse mosquito netting, which will prevent the butterflies from escaping when they develop and permit the much smaller parasites to issue and continue their good work.

REMEDIES.

In the treatment of this species it should be kept in mind that other "worms" and other cabbage pests, are more often present than not.

Arsenicals.—The best remedy is one of the arsenicals; and Paris green and arsenate of lead are preferred to others in common use. If the former is used it may be applied either dry or wet, preferably, however,

¹ Among other predaceous enemies observed in this country are the wheel bug (*Arilus cristatus* Linn.) and the armed soldier bug (*Podisus spinosus* Dall.). The cabbage worm is also parasitized by the Tachina fly *Exorista vulgaris* Fall. The writer has a list of 10 additional European parasites.

²*Micrococcus piperidis* Burrill. ³*Autographa (Plusia) brassicæ* Riley.

as a spray, at the rate of about 1 pound of the poison to 150 gallons of water. It should be applied when the plants are first set out, so as to insure the poison reaching the young larvæ before they have burrowed far into the heads. Other applications should follow as required. These can be made with absolute safety until the heads are about half formed, and, for that matter, even later, as the poison disappears from plants almost completely within three or four weeks after application.¹

Bran mash.—A mixture of bran with Paris green, one of the standard remedies for cutworms as well as grasshoppers, is, according to the testimony of some who have used it, successful against “cabbage worms,” and should be tried against the present species. Any arsenical can be employed in the preparation of this mixture. It is best to mix the bran with water and sugar before adding the poison. The proportions are 2 or 3 ounces of sugar or other sweetening, and about 1 pound of bran, to a gallon of water; so as to make, when stirred, a mixture that will easily run through the fingers. In its application it is merely sprinkled, either wet or dry, over the affected plants.

The hot-water remedy.—As long ago as 1883 water, at a temperature of about 130° F., was advised as a remedy for this cabbage “worm.” It does practically no harm to the plants and kills all insects with which it comes in contact. It is scarcely applicable to large fields, however, on account of the difficulty of maintaining the proper temperature.

Kerosene emulsion is not as effective as the arsenicals, because in its application it is necessary for the spray to come into direct contact with the larvæ in order to kill them.

Pyrethrum is not so useful as an arsenical. Of its effectiveness Dr. James Fletcher, who still advocates its use in Canada, wrote in 1891 that “diluted with four times its weight of common flour, and then kept tightly closed for twenty-four hours (before use), leaves nothing to be desired, and thousands of dollars are yearly saved to small growers, who most need assistance.” Pyrethrum is rather costly and, though said to discolor the leaves, has the advantage of not being poisonous to human

¹ *Harmlessness of arsenicals when properly applied.*—Chemical analysis has shown that cabbage which has been dusted or sprayed with an arsenical in the way prescribed, and then prepared for cooking in the usual manner a week later, has not even a trace of arsenic remaining. The use of arsenicals against cabbage worms is almost universal in the United States, although growers are sometimes loath to acknowledge the fact for fear of the loss of customers who are not fully acquainted with the harmlessness of the remedy. There are no authentic recorded instances known to the writer of poisoning from the consumption of cabbage treated with an arsenical. According to Gillette, 28 cabbage heads, dusted in the ordinary way, would have to be eaten by a human being at one meal in order to produce poisonous effects. Still it is preferable, in order to avoid all danger, to use other insecticides in the case of vegetables that are to be eaten soon. On this head it might be well to cite the experience of a Virginia market gardener who dusted his cabbages with Paris green and flour, omitting to inform his family of the fact. A day or two later he ate heartily of this cabbage, as did others, and afterwards was questioned by his wife in regard to the peculiar powdery substance on the heads. Although poisoning was anticipated, no ill results followed.

beings or domestic animals. If it is not used in liberal quantity, however, a proportion of the caterpillars are merely numbed by this mixture and recover. Younger caterpillars are more susceptible.

Hand-picking.—For the kitchen garden where, for obvious reasons, it is undesirable to use arsenicals, hand-picking is sometimes practiced, especially when plants are first set out.

The corn-meal remedy.—According to Prof. L. Bruner, corn meal dusted on cabbage causes the “worms” to drop off, and protects the crop until the meal is washed away by rain. It is applied in the morning while the dew is on and is said to act as a deterrent.

Clean farming and trap crops.—If cooperation in clean methods of farming and in the use of arsenicals could by any possibility be secured, much of the loss due to the ravages of this pest might be averted. The practice of leaving cabbage stalks in the field after the main crop is off is a reprehensible one. All remnants should be gathered and destroyed with the exception of a few left at regular intervals through a field as lures for the females to deposit their eggs. Such stalks, being useless, should, where feasible, be freely poisoned with arsenicals so that the last generation will have no place to develop in the fields.

The utilization of natural enemies.—It is matter of common observation, frequently recorded, that the two parasitic enemies of this species (*Pteromalus puparum* and *Apanteles glomeratus*) do excellent service in reducing the numbers of their host. The means by which they can be encouraged is described on page 6.

Attempts have also been made to utilize diseases of this insect for its control, but without very encouraging results.

Hellebore will kill this “worm,” but is not as satisfactory a remedy as the arsenicals.

Trap leaves.—A remedy suggested by one of our correspondents was tested by the writer against this and other cabbage “worms,” including the looper, and found worthless. It consists in placing fresh cabbage leaves over the heads at night, the supposition being that the “worms” will gather under these traps and can be destroyed next morning.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., April 28, 1905.

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist.

BLACK CHECK IN WESTERN HEMLOCK.By H. E. BURKE, *Special Field Agent.*

ECONOMIC IMPORTANCE.

Black check is the lumberman's name for a common defect, consisting of a dark brown or blackish resinous scar, in the wood of the western hemlock. A few layers of the wood beneath this scar are slightly stained for a short distance around, and all of those above are thickened, curled, or in some way abnormal. When seen in a quarter-sawn board (radial section) the defect appears as a small, thin seam (fig. 1) from one-half to one inch long, with one side curly. In a bastard-sawn board (tangential section) it is an oval or circular spot (fig. 5, *g*) that varies in diameter from one-half to one inch. In both cases it lies with the grain of the wood.

Hemlock timber growing on lowlands is often seriously affected, while that on higher land, especially above an altitude of 1,800 feet, appears to be free from the injury. In a large quantity of box stock cut from lowland timber, nearly every board examined by the writer contained numerous examples of the defect.

Timber badly affected with this defect is nearly worthless for finishing, turning, staves, and woodenware, for which it would otherwise be excellent. The injury is very conspicuous in bastard-sawn lumber, unfitting it for finishing or turning, while in that quarter-sawn (fig. 1) or cut across the grain it is apt to form an open seam which renders it worthless for staves and woodenware, where tightness is required, but it would appear that it is not materially detrimental to timber for construction and other purposes.

Taking into consideration the common occurrence and injurious effect of the blemish in lumber for certain purposes, and the large amount of timber concerned, the total loss caused by the check must be considerable.



FIG. 1.—Longitudinal section of a board approximately quarter-sawn containing checks (radial section) (original).

This form of injury is due to the attack of the bark maggot (*Cheilosis alaskensis*) subsequent to primary injury by the hemlock barkbeetle (*Hylesinus* n. sp.).

HISTORICAL.

In 1902 Mr. Edward T. Allen, of the Bureau of Forestry,¹ described the defect which he had found to be caused by a maggot or larva of an unknown fly.

In 1903-4 the writer made special investigations of the trouble, under instructions from Dr. A. D. Hopkins, to determine: (1) The species which is responsible for the damage; (2) the life histories and habits of the principal species and closely related forms, their natural enemies, etc.; (3) whether or not the larvæ are capable of entering healthy, uninjured bark; and (4) the character and causes of previous injuries which induce attack.

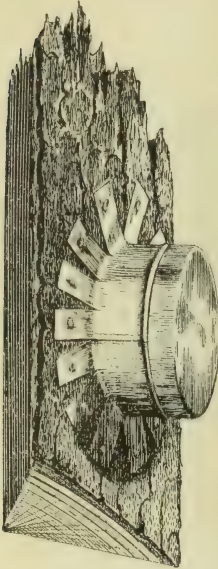


FIG. 2.—Box cage fastened to side of tree to catch adult fly (original).

The principal localities in which the work was carried on in connection with that on forest insects in general, were Hoquiam, Aberdeen, Satsop, Copales, Kent, Puyallup, North Bend, South Bend, and Seattle, in the State of Washington, and the vicinity of Portland, Oreg.

The first examination of infested trees was made in August, 1903, when maggots of various sizes were found to be quite common in the bark of the trunks of living trees. Their presence was indicated by small masses of resin on the surface of the bark. In and beneath each of these a single maggot was at work in a cavity or hole which extended to the surface of the wood, where there was a wound, evidently caused by this insect. Similar wounds, partially healed, and others several years old were found in the same trees, from near the outer layers of the sapwood to layers deeply buried in the heartwood. The latter were readily recognized as the black-check defect and there was no doubt left as to their being caused by this insect, which should, therefore, be hereafter known as the hemlock bark maggot.

Experiments with different methods of rearing the adult insect were at once started. At first the infested resin masses with a portion of the adjoining wood were cut out and placed in jars and tin boxes, but they soon dried up or molded. Then cages of netting placed over the resin masses on the trees were tried. These proved too flimsy and were hard to examine. Finally, cages were made from small baking-powder and spice cans, by knocking off the bottoms, cutting the sides into narrow

¹ Bur. For., U. S. Dept. Agric., Bul. 33, "The Western Hemlock," pp. 19, 20, 23.

strips, and punching holes for tacks in the tips of the strips (fig. 2). This was found to be admirably adapted to the work; it was durable, could be readily fitted to any surface, and was easily examined by simply removing the lid.

The investigations were started too late in the season to secure the pupæ or adults, but many larvæ in various stages of development were collected and studied, and a number of the infested wounds were covered with the tin cages.

The most important result of the first season's work was the discovery that the primary cause of the attack and subsequent injury by the bark maggot was the work of the hemlock barkbeetle (*Hylesinus* n. sp.) (fig. 3, *a*)¹ which was found excavating short burrows (fig. 3, *b*, *c*) in the healthy bark, and through it to the surface of the wood, where a small wound was made, causing a slight flow of resin (fig. 3, *f*). These burrows were evidently made by the beetles for the purpose of obtaining food, and not for the purpose of depositing eggs, since neither eggs nor larvæ of the beetle were found, and the burrows were soon abandoned. Some of these food burrows were healed over without further injury to the wood, while others were open and contained a small amount of resin. These abandoned galleries, with the resin, formed ideal places for the young bark maggots to begin their work, and were, apparently, utilized in preference to any other wounds.

The investigations of 1904 were more successful. Upon the first examination of the breeding cages on April 27 one adult male was found. On April 30 a female emerged, and May 8 two males were secured from resin masses placed in cages in the laboratory. Another female was

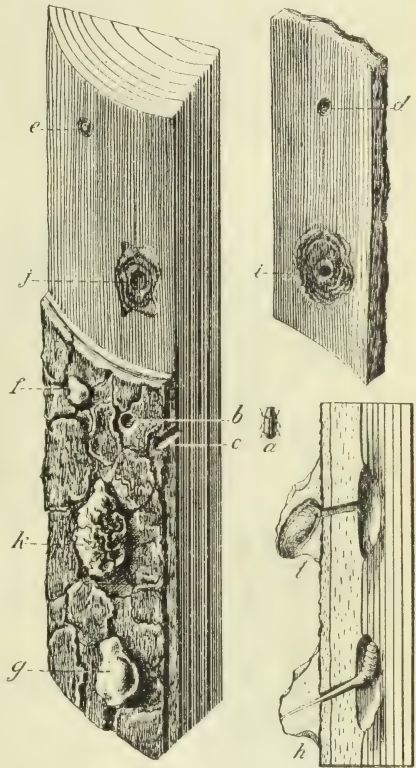


FIG. 3.—Development of the black check in western hemlock: *a*, the beetle (*Hylesinus* n. sp.) that makes the primary injury—natural size; *b*, entrance of beetle in outer bark; *c*, longitudinal section of a similar entrance; *d*, same as *b*, showing wound in outer sapwood; *e*, same, showing wound in inner bark; *f*, resin exuding from an entrance after beetle has gone; *g*, fresh resin mass on outer bark, indicating hemlock bark maggot at work; *h*, longitudinal section of similar mass, showing position of maggot; *i*, maggot wound in inner bark; *j*, same, in outer sapwood; *k*, resin mass after maggot work is done and the pupa is formed; *l*, longitudinal section of similar mass, showing pupa, the wound beginning to heal (original).

¹ Bul. No. 48, Div. Entom., U. S. Dep. Agric., p 20.

taken on May 10, while it was flying in the sun in a field near the forest. No adults were found in the cages or collected after May 10, which would indicate that in this locality the adults emerge during the last of April and the first of May. Specimens of the fly were sent to Mr. D. W. Coquillett, who identified them as *Cheilisia alaskensis* Hunter.

The last examination of the field breeding cages was made on October 10. A number of the resin masses that were caged in October, 1903, still contained larvæ. This would indicate that the insect lives several years in the larval state. The fact that larvæ of various sizes were

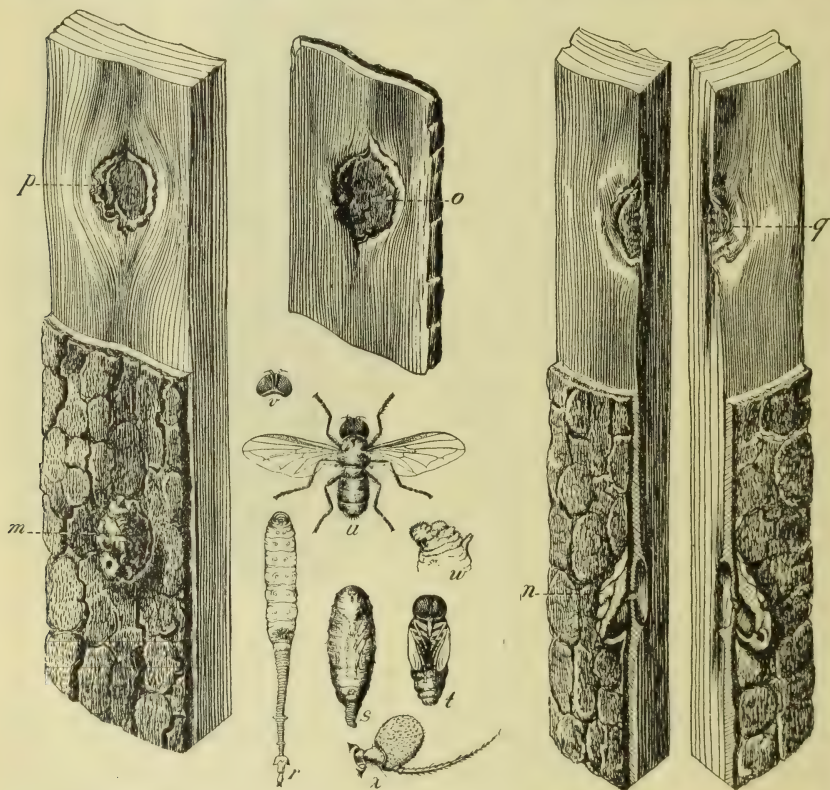


FIG. 4.—Hemlock bark maggot (*Cheilisia alaskensis*): *m*, Resin mass with exit hole, adult fly having emerged; *n*, longitudinal section of similar mass, showing wound in inner bark and outer sapwood, pupal chamber and exit hole in outer pitch mass, and original beetle entrance connecting them; *o*, healing wound in inner bark beneath mass like *m*; *p*, healing wound in outer sapwood beneath mass like *m*; *q*, longitudinal section of wound *p*; *r*, maggot; *s*, puparium; *t*, pupa; *u*, adult, male; *v*, head of female—all about twice natural size; *w*, larval head—enlarged about 20 times; *x*, antenna—enlarged about 45 times (original).

found at all times of the year and adults only in the spring strengthens this belief.

LIFE HISTORY AND HABITS OF THE HEMLOCK BARK MAGGOT.

The female fly was not observed ovipositing, nor was the egg found, but young larvæ were collected from the barkbeetle wounds. It there-

fore seems evident that the egg is laid on or in the slight flow of resin that exudes from such a wound (fig. 3, *f*). No evidence was found that the larva could make an independent entrance through the bark.

DESCRIPTION OF THE STAGES.

The larva.—The larva (fig. 4, *r*) is a whitish maggot with a small, wrinkled head almost buried in the front end of a plump, subcylindrical, segmented body that terminates behind in a long, telescopic, protractile tail. The head (fig. 4, *w*) has a pair of stout, black, forked mandibular hooks, and is densely clothed with short brown spines. When examined with a microscope, a pair of small branched feelers (antennæ) are found just above the hooks. The body seems smooth to the naked eye, but it is quite thickly covered with minute spines. Just back of the head, upon the dorsal surface of the first segment, is a pair of widely separated, small, fleshy tubercles. Each bears a dark brown breathing organ (spiracle). Most of the segments have a pair of fleshy appendages, probably false feet, on their ventral surface. Upon the ventral surface of the last segment, and surrounding the anus, which opens there, are often seen five or six heavily convoluted, bladder-like protrusions. These are probably the rectal glands.

The tail is about the same length as the body. It bears several pairs of the fleshy foot-like organs, and terminates in a dark-brown fork, each branch of which is armed with a whorl of four strong plumose bristles. It is simply a long breathing tube that may be lengthened or shortened at will to meet the varying depth of the resin mass covering the body. The tip, or fork, bears and protects the spiracles, which must always be kept out to the air. The full-grown larva, including tail, is from 0.6 to 0.8 inch in length, and 0.08 to 0.12 inch in width at its largest part.

The puparium.—The puparium (fig. 4, *s, t*) is formed within the last larval skin. The larva lies doubled up with the tail bent over the back and the head just within the outer surface of the resin mass. The tail shortens up, appears to lose its breathing function, and the body becomes more compact and solid. The two spiracle-bearing tubercles on the back of the first segment become elongated into horns, and form the breathing tubes. The larval skin does not seem to become very much thickened, nor any darker, as is usually the case in related forms. It remains quite transparent and the outlines of the puparium can be seen through it quite plainly. The puparium, including the inclosing larval skin, is 0.28 to 0.36 inch in length, and 0.12 to 0.16 inch in width.

The adult.—When full development is reached, the head of the larval skin is pushed out and the adult emerges. This usually takes place in April or May. The adult (fig. 4, *u*) is a small black fly, about 0.36 inch in length, 0.12 inch in width, with wings 0.32 inch in length, and is rather densely covered by medium black hairs. The male is more

slender than the female, which has a rather broad pointed abdomen. The eyes of the male are contiguous on the top of the head, while those of the female (fig. 4, *v*) are quite widely separated. Little is known of the habits of the adults. Though carefully sought for, only one specimen was taken in the field. This was flying in the sun in a little meadow at the edge of a forest. The species was described¹ from a single female taken at Cook's Inlet, Alaska. There is also a female from Yakutat, Alaska, in the U. S. National Museum Collection.

HABITS OF THE LARVA.

The larva is usually found in the wound (fig. 3, *h*), surrounded by the soft resin. The head and body lie in the inner part next to the sapwood, while the tail extends out through the bark and outer resin mass, with the spiracles opening into the air. The cambium, or growing layer, which is composed of soft, living, outer sapwood and inner bark, is bruised and torn by the mandibular hooks until quite a wound is made. This is enlarged as its occupant grows in size. The resin is pushed out of the entrance and forms an irregular, globular, reddish-gray mass on the outer bark (fig. 3, *g*, *k*, and fig. 4, *m*).

Breathing through its tail and feeding on the sap and soft tissues of the tree, the larva lives in the wound until it becomes full-grown. This takes, in some cases at least, several years. Some larvæ, from eggs laid, probably, in May, 1903, had not changed to adults in October, 1904. All sizes of larvæ are found at all seasons of the year, but the adults during April and May only. The wounds (fig. 3, *i*, *j*) show that as many as five successive layers of new growth may be eaten, although the usual number seems to be three. These facts seem to indicate that living representatives of several broods may be found at any time, and that the length of the larval stage is variable. It is probable that under unfavorable conditions it may be prolonged to four or five years, while if the conditions are favorable it may be shortened to one year.

Although the larva is usually found in the wound as described before, it sometimes moves around in the outer resin mass and even on the outer surface of the mass. In the spring the fully developed larva withdraws to the outer mass to pupate (fig. 3, *l*).

The primary wound made by the barkbeetle through the bark remains the same size as the beetle leaves it, and the bark maggot occupies the chamber between the inner bark and wood. Both entrance and chamber are filled with resin. The completed wound (fig. 4, *o*, *p*, *q*), therefore, consists of the beetle burrow, which is about 0.08 inch in diameter, through the outer and inner bark to the inner chamber, which is one-half inch to 1 inch in diameter. The external resin mass is 0.6 inch to 1 inch in diameter, and 0.4 to 0.6 inch in depth.

¹ W. D. Hunter, Can. Ent., Vol. XXIX, p. 124, June, 1897.

As soon as the maggot leaves the inner chamber the irritation ceases and the wound begins to heal. The cambium grows down into it year after year, and the annual growth of wood formed there slowly covers it over until in three or four years it is completely buried (fig. 5) beneath the new growth and thus forms the black check.

As the wood grows down into the wound in healing it over, a depression is formed in each new layer, but sometimes the new layer thickens around the depression and forms an elevation above the surrounding surface. In both cases an ornamental curl is formed that will show as a bird's-eye effect in bastard-sawn or longitudinal sections of the wood.

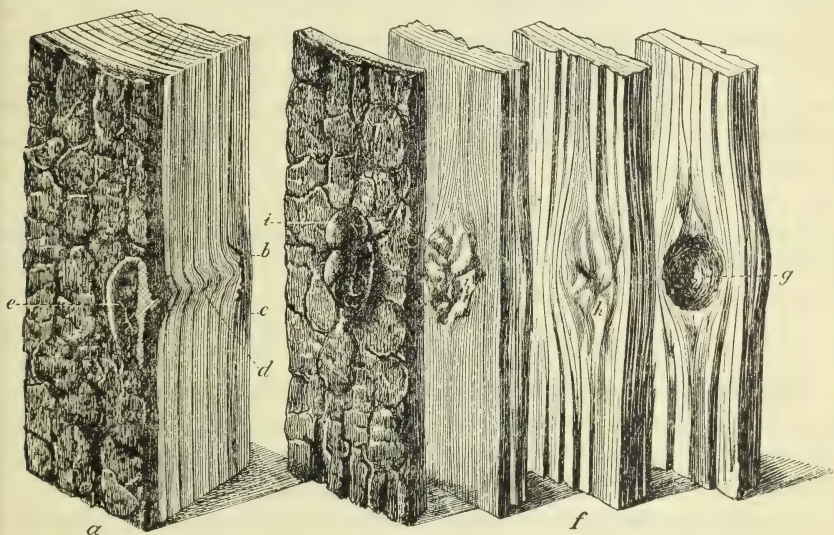


FIG. 5.—*a*, Longitudinal section of wood containing a black check; *b*, the check; *c*, the stain in the wood beneath it; *d*, the curls in the wood covering it; *e*, the resin mass on and in the bark; *f*, section *a* split into four sections to show tangential views; *g*, tangential view of check; *h h*, tangential view of curls; *i*, black spot or old resin mass (original).

NATURAL ENEMIES.

Two hymenopterous parasites were bred from the syrphid puparia. Dr. Wm. H. Ashmead, of the U. S. National Museum, identified one of these as an ichneumonid (*Syrphoctonus maculifrons* Cr.) and the other as a chalcidid (*Eutelus flavipes* Walk.). Both species are fairly common, and probably aid greatly in keeping the trouble in check.

Syrphoctonus maculifrons Cr.—This is a small wasp-like ichneumon fly about 0.36 inch in length. It has a dark body marked by a few white patches at the bases of the wings and legs. The face is nearly covered by a square of white, and the legs are reddish brown. The abdomen of the male is more slender than that of the female, and the white square on the face is larger. The earlier stages are not known. Pupation takes place in the body of the maggot in the outer resin mass. The adult emerges during the latter part of June or the first of July.

Each maggot furnishes subsistence for but a single parasite. Adults were bred from resin masses of both the hemlock and the lowland fir bark maggots.

Eutelus flavipes Walk. is one of the small chalcidid flies. The females have dark metallic-green bodies, cherry eyes, light brown legs, rather dark antennæ, and are about 0.12 inch in length. The males are smaller, about 0.08 inch long, and have a broad yellow band across the abdomen. Their bodies are a lighter green and the legs and antennæ are yellow. Each maggot supports a number of parasites, usually about a dozen. The pupæ are formed in the body of the host in the outer resin mass. The adults emerge during the latter part of June. This species was bred only from the hemlock resin masses.

These two parasites were the only natural enemies found. There was no evidence of any bacterial or fungous disease, and the maggot is so concealed in the bark and resin that it is well protected from predaceous enemies.

ASSOCIATES.

Two small pill beetles (*Amphicyrta simplicipes* Mann. and *Simplocaria nitida* Mots.) were frequently found on and near the resin masses. Their relation, if any, to the syrphid was not determined.

METHODS OF PREVENTING LOSSES.

Since the black check is the result of the work of the insects during past years, or even centuries, and is thus distributed all through the wood of the trunks of the matured affected trees, the only methods which appear to be available for preventing losses are:

(1) Where clear stuff is required, select timber which, as indicated by the absence of the old resin masses on the bark, is free from the trouble.

(2) Utilize timber from badly affected trees for box material and other purposes where the checks are not objectionable.

(3) Utilize the bird's-eye or curled wood for natural-wood finish.

BARK MAGGOTS IN OTHER TREES.

THE LOWLAND FIR BARK MAGGOT.

In 1903, while studying the black check of the hemlock at Satsop, Wash., a similar trouble was discovered in the white or lowland fir. The insect causing it was reared and proved to be *Cheilisia hoodianus* Bigot, a species closely related to the hemlock fly. The maggot is very similar in size, appearance, and habits. The adult is a trifle larger and not so dark in color. The thorax is dark brown, and the abdomen a light chocolate. The emergence of the adult takes place a little later in the season than that of the hemlock species. Most of those reared emerged about the middle of May, but the last one did not come out of the resin mass until August 12.

The work of the two species is very similar. The fir is a more rapidly growing tree than the hemlock and the wounds under the bark, therefore, go deeper into the sapwood. These wounds, also, occur more often in patches. The primary injury is made by several species of barkbeetles, viz, the western hemlock barkbeetle (*Hylesinus* n. sp.), the larger fir-tree barkbeetle (*Hylesinus granulatus* Lec.), and probably other species.

Two specimens of the parasite *Syrphoctonus maculifrons* Cr. were bred from the resin masses. No other enemies were seen.

Satsop was the only place where the trouble was noticed. The amount of damage done and the distribution of the insect causing it are not known.

THE ALPINE FIR BARK MAGGOT.

On October 24, 1904, a bark maggot was found in a resinous wound on the trunk of an alpine fir at Smith's Ferry, Boise County, Idaho. The wound seemed to have been started from an old limb scar. Only one specimen was found. It resembled the maggots of the hemlock and lowland fir, and is probably the larva of another species of *Cheilisia*. The amount of damage it causes was not determined.

THE SITKA SPRUCE BARK MAGGOT.

A maggot closely resembling the other species, except that it has a short tail, is quite common in the wounds on the trunks of Sitka spruce. It is usually found in the pitch around the edges of the large resinous wounds caused by the spruce pitch-worm (*Parharmonia piceæ* Dyar). Several maggots live in the same wound, and the irritation produced by their feeding keeps it open for so long a time that an ugly scar is formed in the wood. Several generations may live in the same wound. Pupation takes place in the drying resin of the wound. This is probably a species of *Cheilisia*. Hoquiam, Wash., was the only place where the trouble was noticed.

THE YELLOW PINE BARK MAGGOT.

A dark, subcylindrical dipterous puparium was very common in pitch exuding from axe and other wounds in the bark of young yellow pine (*Pinus ponderosa*) trees at Moscow Mountain, Idaho, and barkbeetle (*Dendroctonus* sp.) and sapsucker wounds in the bark of the young trees of yellow pine, and the lodgepole pine (*Pinus murrayana*) at Smith's Ferry, Idaho. No adults were reared. The species is probably a syrphid, possibly a *Cheilisia*, though the puparium does not resemble those of *Cheilisia alaskensis* and *hoodianus*. The amount of damage done is unknown.

CONCLUSIONS.

(1) Western hemlock timber growing on low land is often affected by a defect known as black check, which renders a large percentage of the

wood worthless for finishing, staves, and woodenware, but apparently is not seriously detrimental to timber for other purposes.

(2) The black check is caused in nearly every case by an injury to the cambium (growing layer) of the trunk by the hemlock bark maggot, *Cheilisia alaskensis* Hunter. Somewhat similar defects may be caused by barkbeetles, bark-borers, sapsuckers, or anything that makes a wound in the cambium, which afterwards heals.

(3) The maggot enters the bark through an abandoned food burrow made by the hemlock barkbeetle (*Hylesinus* n. sp.). It gradually enlarges the burrow into a small wound, in which it lives for several years, feeding on the sap and cambium. In the spring, when full grown, it pupates in the resin mass which has formed on the outer bark around the entrance to the wound. The puparium soon changes to the adult, which emerges in April or May. The egg is probably laid on the resin exuding from the abandoned gallery of the barkbeetle.

(4) A near relative (*Cheilisia hoodianus* Bigot) of the hemlock bark maggot causes, in a similar manner, a black check in the timber of lowland, grand, or white fir (*Abies grandis*). It enters the bark through the abandoned food burrows of several species of barkbeetles.

(5) The alpine fir (*Abies lasiocarpa*), the Sitka spruce (*Picea sitchensis*), and probably many other trees are injured more or less by bark maggots that enter wounds and enlarge them or keep them open until the conditions are such that checks form in the timber.

(6) For preventing losses in timber cut for purposes requiring clear stuff, select trees growing at altitudes above 1,800 feet and those at lower elevations which are free from the black indicating spots (old resin masses) on the bark.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., May 24, 1905.

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist.

THE CABBAGE HAIR-WORM.

By F. H. CHITTENDEN,

In Charge of Breeding Experiments.

Not since the "kissing-bug" craze which originated in Washington, D. C., in June, 1899, and spread generally throughout the country, has there been anything like such a furor as was created by the discovery of the so-called "cabbage snake," a species of hair-worm, in the heads of cabbage in Tennessee, South Carolina, and Louisiana, in the fall of 1903. That year the cabbage-snake scare was practically confined to Tennessee and neighboring States southward. The first specimen of *Mermis albicans* Diesing (fig. 1), which is the cause of the trouble,¹ was identified from McCays, Tenn. This creature and its still somewhat mysterious occurrence in cabbage has become a matter of much perplexity and annoyance to many of our correspondents, to economic entomologists, and to chemists and physicians of the States where the *Mermis* most abounds. Many reports have been received from reliable correspondents of rumors of persons being poisoned by eating cabbage affected by this hair-worm. Some of these were gleaned from the daily press, and many clippings of the "yellow journalism" order were received. Among them were alleged reports from a physician who stated that when cabbage affected by hair-worms was eaten it produced instant death, and from a "State chemist" who made an examination of the worm and reported that it contained enough poison "to kill eight persons." In Raleigh County, W. Va.,



FIG. 1.—Hair-worm (*Mermis albicans*)—natural size (original).

the cabbage crop was reported a complete failure, and "there was enough poison contained in one worm to poison 25 men." It should be unnecessary to add that none of these reports had any foundation in fact. Nevertheless the *known* presence of the hair-worm in an affected district seriously injured the demand for cabbage there, causing very

¹So many inquiries in regard to the identity of the creature and its alleged poisonous nature were received that a short account was furnished under the title "Hair Worms in Cabbage," in Bul. 44, of this office, pp. 93-95; and similar inquiries are being made to date of publication. During 1904, frequently five or six communications were received daily.

considerable loss to truckers and grocers. The exaggerated reports of 1903 were not seriously considered; and it was a matter of surprise when they were reiterated the following year, and what was in reality a hoax assumed most serious proportions, not alone because of widespread alarm caused by erroneous reports of loss of life, but also because of the very material loss to cabbage growers and others who handled this commodity, and the decided extension of the area in which the hair-worm was detected. Encouraged by erroneous reports, evidently incited in many cases by unscrupulous persons, the scare soon became widespread, causing general fear of poisoning from Virginia and West Virginia southward through the same States as were affected in 1903, and into Florida, and in addition westward to Kentucky, Illinois, Iowa, Missouri, Oklahoma, and Colorado.

DESCRIPTIVE.

The cabbage hair-worm is aptly described as resembling a piece of basting thread, of the thickness of a strand of corn silk, of a darning needle, of a No. 36 or No. 40 thread, or like a horse hair; white in color; found coiled, or coiling and uncoiling; stretched at length or crawling in cabbage heads; its length varies from 2 to 9 inches, but *reports* have been received of a creature found in the heads of cabbage measuring 9 feet! The imagination of newspaper writers as to color runs riot through "green, white, light red, olive green, and yellow."

As a matter of fact this hair-worm is filiform or thread-like, and when it attracts attention on cabbage, measures generally from 4 to 8 inches. One specimen, doubtfully of the same species, measured when uncoiled 22 inches or nearly 2 feet. The color is white or whitish, although it sometimes has a pale brownish or greenish tinge.

THE SPECIES IDENTIFIED.

Many popular names have been bestowed upon this worm, including "cabbage snake," "snake," "snake worm," "serpent," "reptile," "cabbage rattlesnake," occasionally "cabbage worm," and seldom if ever hair-worm. Most specimens submitted for identification have proved to be what is known as *Mermis albicans* Diesing.¹ This creature is neither an insect nor a snake, but one of the hair-worms of the order Gordiacea. The principal species of this order belong to the genera Gordius and Mermis, and were treated somewhat at length in 1877.²

¹ The studies of Diesing, Siebold, Meissner, and others have led to the expressed belief that *M. albicans* is merely the mature sexual form of *acuminata*, the latter name having priority.

² First report of the U. S. Entomological Commission, published in 1877 (pp. 326-334). The hosts of hair-worms include many Orthoptera (grasshoppers or locusts, crickets, and katydids). They are sometimes parasitic on beetles, more particularly Carabidæ or ground beetles, on bees and flies, on caterpillars of butterflies and moths, and even on snails.

Mermis albicans was received during 1903 in a piece of apple, found coiled near the seed. This species is known to be parasitic on the codling moth or "apple worm" (*Carpocapsa pomonella* Linn.), which accounts for its presence in this instance (l. c., p. 327). It is also parasitic on certain common and destructive forms of grasshoppers, *Melanoplus spretus* Thos. or rocky mountain locust, *M. differentialis* Thos. or differential locust, *Schistocerca americana* Dru., and *Dissosteira carolina* Linn.¹

LOSSES OCCASIONED BY RUMORS OF THE POISONOUS NATURE OF THE HAIR-WORM.

The presence of this hair-worm in cabbage and the unfortunate notoriety which has been given it, including the circulation of the merest rumors, mostly vague and uncertain, of so many persons being poisoned by eating affected cabbage, has seriously injured the money value of this vegetable very generally throughout the affected States. Although the cabbage hair-worm is not in the slightest degree deleterious to health, the credence given to the most absurd rumors which were circulated has injured cabbage for consumption and hence for sale. In parts of Illinois the fears of growers and purchasers were such that farmers were letting their cabbage go to waste. At Quinter, Kans., quantities of cabbage shipped from Colorado were reported burned because of the presence of the hair-worm. In Tennessee it was estimated that in 1904 fully 85 per cent of the cabbage crop of the State was lost—in fact, a sudden and complete suspension of the industry was actually caused. Similar reports were received from various portions of Missouri, Iowa, West Virginia, and Virginia. "In Cheatham, Smith, Franklin, Coffee, Bedford, and other counties [in Missouri] hundreds of barrels of sauerkraut were destroyed through fear that the dreaded snake might be a part of the ingredients." At Columbia, Mo., hundreds of dollars worth of cabbage were lost. Many gardeners claimed that they could not sell a single head on account of the "snake scare."

ALLEGED SICKNESS AND DEATH CAUSED BY HAIR-WORMS.

The general impression in regard to the poisonous nature of the cabbage hair-worm has been mentioned, yet considerable differences of opinion prevail. To repeat alleged deaths and poisoning in detail might have the opposite effect from that for which this circular was prepared. Stories were circulated of whole families being poisoned by eating cabbage affected with the hair-worm, sometimes with the reservation that no one knew *personally* of their truth, and that many

¹ The classification and habits of *Mermis* have not been given much study, hence some slight doubt exists as to the species of *Mermis* observed in the case of some of the hosts cited, but if one species will affect both lepidopterous larvæ and grasshoppers, this is evidence of its not being overparticular as to its host.

cases were traced to their source and found to be utterly without foundation. From Tennessee came a report of the death in one town of a man, woman, and six children. In portions of the same and in other States, persons were stated to have been taken ill with pain and vomiting after having eaten cabbage on which the worms were subsequently found. Possibly the consumers had been seized with temporary hysteria, imagining that they had unconsciously eaten many individuals, hence the symptoms. Others were reported severely poisoned or dead. In most cases exact localities were furnished, but names were wanting. In some cases domestic animals were said to have been poisoned; in others cabbage was fed to them without any ill results.

The death of a man and wife and their four children in an Illinois town after eating snake-worm infested cabbage was reported in several newspapers and the family name mentioned:

The entire family of six ate the cabbage at supper and died during the night. A cabbage in the garden was examined and found to contain worms the size of a thread, 8 or 10 inches long and about the color of the cabbage. The cabbage was cut up and fed to animals, and all died. Farmers are destroying all their cabbage. Three persons in the neighborhood have recently died after eating cabbage.

In response to inquiry from this office the postmaster of this town, the name of which is omitted for obvious reasons, wrote December 17, 1904, that efforts were made to locate the origin of the account, but without success.

LIFE HISTORY.

The hair-worms of the genus *Mermis* develop within the body of their host and, according to various writers, when about full grown desert it by rupturing the body wall. These individuals are undeveloped sexually, and characterized by a mouth consisting of a minute aperture, and a minute anal point which is generally curved. On issuing from the host the worm bores into the earth and conceals itself. During this stage in the soil no food is taken, though several months may elapse, the creature hibernating and becoming sexually mature before copulation takes place in the spring. The sexes unite in knots, and the female deposits numerous eggs¹ in the ground. Here the young, which are thread-like like their parents, hatch and burrow upward to the surface, and enter as parasites the bodies of caterpillars and various soft insects, such as are found under leaves and other débris near the ground.

The habits of *Mermis* in Europe have given rise to the belief in a rain of worms. Not infrequently in summer time, after a warm rain at night, swarms of these hair-worms appear on the surface of the earth, whence the supposition that they are rained down.

¹ It might be added that hair-worms positively do not develop from horse hairs.

OTHER WORMS, INSECTS, ETC., MISTAKEN FOR THE CABBAGE WORM.

Numbers of hair-worms other than *Mermis albicans*, the larvæ of sciarid flies, and some species of myriopods, as also angleworms, have been received as undoubted cabbage snakes or as suspects. In fact, gullible people throughout the affected region have literally gone "hunting for trouble" and have sent everything conceivable except the true cabbage worms (caterpillars of moths and butterflies), which are altogether too well known, as suspected "cabbage snakes." Some of these, all, with the possible exception of the myriopods and sciarids, of accidental occurrence on cabbage, will be mentioned.

Mermis spp.—Various species of *Mermis*, related to *albicans* but differing in various particulars, have been received with the usual reports of poisonousness. One species of hair-worm, resembling the "cabbage snake" and possibly the same species, was received from St. Clara, W. Va., in March, 1905, which measured nearly 2 feet in length (22 inches) when uncoiled.

Paragordius varius, a suspect, was not found in cabbage but in water "without visible means of support," in Virginia.

Geophilus spp.—Numbers of myriopods of the order Chilopoda, which includes the centipedes and millipedes, were among this number, nearly all belonging to the genus *Geophilus*. There appear to be no positive records of any forms of these creatures found in the United States inflicting serious injury to man, but certain tropical forms are decidedly venomous. These creatures sometimes attack man, if accidentally handled, but they are not known to occur in cabbage. The poisonous species are large and conspicuous, and therefore not liable to be eaten with food. The species of this genus have carnivorous habits, and there is a possibility that they may destroy some forms of cabbage worms and hence may be beneficial.

Earthworms.—Specimens of earthworms, in bad condition so that identification was impossible, were received from West Virginia and Ohio, where they were mistaken for the cabbage hair-worm.

Sciarids.—The larvæ of sciarid flies were received in several instances from August until October, 1904, chiefly from Tennessee, Virginia, and South Carolina. A correspondent at Duffield, Va., pronounced these maggots poisonous, and said that death had resulted from the use of cooked cabbage in which they had been found. A correspondent at Yokum, Ky., made a similar report.

HAIR-WORMS POSITIVELY NOT POISONOUS.

In spite of repeated published and written statements that the so-called cabbage snake is not poisonous, this fact has not been given very general credence, hence the matter is still imperfectly understood by many. As it is an established fact that none of the hair-worms possess poisonous properties, it was not considered necessary to make any analyses or experiments at this Department to demonstrate their nontoxic quality. However, Dr. Louis Leroy, Nashville, Tenn., who corresponded with this office on this topic during August and September, 1904, undertook to demonstrate beyond peradventure of doubt that the hair-worm could not possibly cause harm to persons eating it or cabbage on which it had occurred, and, although he has already published on the subject

it may be well, for the benefit of skeptics, to repeat in substance his conclusions:

During September he wrote that he had carried on a thorough investigation of the alleged poisonous nature of this hair-worm, and found absolutely nothing toxic connected with it, either when eaten raw or when cooked or on cabbage on which the creature had lived. Efforts to trace every reported case of poisoning in Tennessee resulted in ascertaining that they were all without foundation, no authentic case could be cited, and finally, he says "I am at a loss to understand how such reports could gain credence and ever be published for facts in the daily press." In order to determine whether or not the hair-worm had any poisonous qualities he instituted a series of experiments, using rabbits, guinea-pigs, cats, dogs, horses, and cows, finding that they could all eat the worms, raw or cooked, with impunity. Extracts from the hair-worms prepared with various solvents were also found to be entirely innocuous, administered internally (per orem) and injected hypodermically.

"Believing that possibly these worms might cause decomposition or fermentation in the cabbage, with the production of poisonous substances, the result of the decomposition," he allowed samples of cabbage, both raw and cooked, to decompose with the worms, and then tested the decomposed material for poisonous properties as above, and in no case was any toxic substance obtained. Chemical analyses of the worms and the products of decomposition mentioned were made, and he was unable to find any ptomaine or other isolatable substance of a toxic nature.

As a result the conclusion was reached "that the cabbage snake is entirely harmless, and that public rumors and superstitions are fallacies without semblance of foundation."

WASHINGTON, D. C. *Issued May 17, 1905.*

United States Department of Agriculture,
BUREAU OF ENTOMOLOGY,
L. O. HOWARD, Entomologist.

ROOT-MAGGOTS AND HOW TO CONTROL THEM.

By F. H. CHITTENDEN,
In Charge of Breeding Experiments.

The roots of vegetable crop plants of many kinds are subject to the destructive influence of maggots which injure them severely during certain seasons. Several forms of injurious root-maggots are recognized, but of these there are three species which are much more destructive than the others. The most important are the cabbage maggot and the imported onion maggot, the former a specific enemy of cabbage and

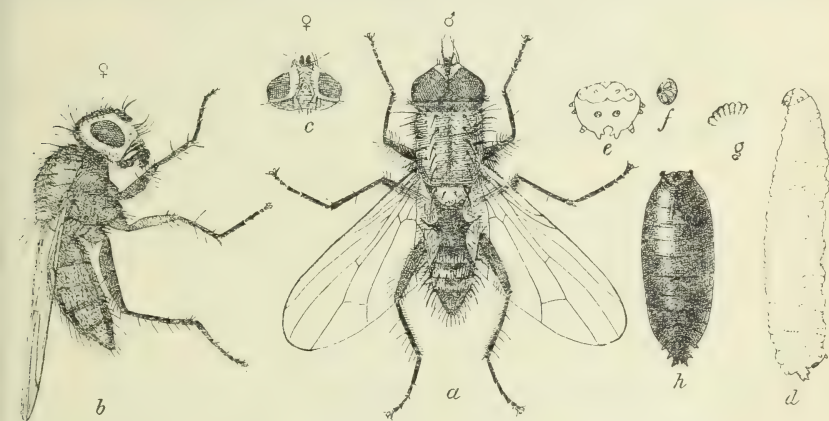


FIG. 1.—Seed-corn maggot (*Pegomya fusciceps*): a, male fly, dorsal view; b, female, lateral view; c, head of female from above; d, larva, from side; e, anal segment of larva; f, anal spiracles; g, cephalic spiracles; h, puparium—all much enlarged (author's illustration).

other cole crops, the latter of the onion. A third species, the seed-corn maggot, attacks the sprouting seeds of both onion and cole crops and of a considerable variety of other plants, afterwards working into the roots and stalks beneath the earth's surface. As the last-mentioned insect is nearly omnipresent and omnivorous, it will receive first consideration.

These species all belong to the genus *Pegomya* (Phorbia) of the dipterous family Anthomyiidae.

THE SEED-CORN MAGGOT.

(*Pegomya fusciceps* Zett.)

Vegetable growers frequently find that planted seed fails to develop, and, on looking for the cause, discover a small white maggot which, from early-observed occurrence on seed corn, has been termed the seed-corn maggot. In more recent years it has often been associated with injury to beans, whence another name, "bean fly." Many other vegetables

are subject to damage, cabbage, turnip, radish, peas, onions, beets, and seed potatoes being often much affected. This insect, which is generally distributed in the United States, is shown in its different stages in figure 1. It resembles the common house fly. The particularly distinguishing characteristic of the fly is a row of short bristly hairs of nearly equal length on the inside of the posterior tibiae or shanks of the male (fig. 1, *a*). The length of the wing is about one-fifth and of the body about one-sixth of an inch. There is little doubt that the insect is of European origin and that it is increasing in destructiveness in this country.¹

In its earlier stages, also, the seed-corn maggot resembles the house fly. The maggot is footless and cylindrical, presenting in profile the appearance represented at *d*. It measures about one-fourth inch in length and about 0.04 inch in width. The color varies from nearly white to pale yellowish.² The maggot transforms into a puparium (*h*), barrel-shaped, of elliptical outline, and pale brown in color, measuring about 0.15 inch in length and 0.05 inch in diameter.

Indications are that there are several generations of this species annually, one developing in the North in June from seedlings, and later ones from roots, dead or dying plants, and other refuse.³

METHODS OF CONTROL.

Owing to the difficulty of destroying root-maggots and other subterranean pests and the cost of chemicals for the purpose, growers depend largely upon methods of prevention. To be thoroughly effective these methods should be employed *before the insect's eggs are laid*.

Sand and kerosene.—A common method for deterring the parent flies from depositing their eggs consists in placing sand soaked in kerosene—a cupful to a bucket of dry sand—at the base of the plants, along the rows. This mixture will also kill young maggots that might attempt to work through it.

Carbolic-acid emulsion.—For all three forms of root-maggots which we are considering, a carbolized form of kerosene emulsion is effective. This is prepared by adding to 1 pound of soap boiled in 1 gallon of water, one-half gallon of crude carbolic acid, and diluting the whole with from 35 to 50 parts of water.⁴ This mixture is applied about the stalks of the plants affected. It is best to use it a day or two after the plants are up, or are transplanted, and repeat every week or ten days until about the third week in May, in the North. Farther south these applications must be made earlier in the season.

¹A more extended notice is furnished in Bul. 33, n. s., Div. Ent., pp. 84-92.

²In all material examined there are only 6 or 7 cephalic spiracles (fig. 1, *g*), whereas in the other root-maggots here considered there are 11 or more.

³There is evidence that another maggot has been confused with this species.

⁴The mixture is effected according to directions furnished in Farmers' Bulletin 127, p. 22 (1903 ed.), which will be furnished on application.

The use of mineral fertilizers.—Mineral fertilizers are useful as deterrents, particularly when employed just before or after a shower has thoroughly wet the ground. The principal fertilizers for this purpose are kainit, nitrate of soda, and sulphate or chlorid of potash. They may be used as top dressings before planting; or, if not employed until afterwards, they should be applied as nearly as possible to the roots, the earth being turned away from the plants for this purpose. These fertilizers possess the advantage of acting also as a stimulant to plant growth, thereby facilitating recuperation from root-maggot attack.¹

Danger from use of organic fertilizers.—Stable manure and organic fertilizers are apt to induce infestation, since the species under consideration is well known to develop in excrement and other decomposing material. Numerous instances of this have come to the writer's knowledge during recent years. It is advisable, therefore, to avoid the use of manure, rotted leaves, or other organic fertilizers, and to avoid planting in fields in which there have been infested or diseased plants.

Hand methods.—As soon as seed fails to appear at the proper time or the plants show signs of wilting and maggots are found to be present, the seed may be hoed out or the injured plants pulled and destroyed, together with the young maggots.

Most of the methods mentioned above have been used with success against onion maggots and other root-feeding species, and are all that is required in many cases of ordinary infestation of vegetable roots.

THE CABBAGE MAGGOT.

(*Pegomya brassicae* Bouché.)

Cabbage and related cruciferous crop plants frequently suffer severe injury from the attack of the cabbage maggot. Young plants are most seriously affected, the maggots eroding the outer surface and boring into the interior of the roots, devouring the tender rootlets and frequently penetrating into the lower portion of the stalk.

This insect, known also as the radish maggot, is an imported pest, and was first noticed ruining cabbage, cauliflower, and similar plants in New York State about half a century ago. It does most serious injury throughout the northern tier of States and Canada, attacking all forms of crucifers, whether wild or cultivated. In that region it is the cause of more or less loss to these crops year after year, but as with other destructive insects, it is much more abundant in some seasons than in others. Since 1902 it has not only been exceedingly destructive, but

¹ It is frequently necessary to use these fertilizers in large quantities. In cabbage fields a fertilizer of the proper composition is applied before planting at the rate of 1,000 to 1,500 pounds to an acre. After the plants have started growth, a top dressing of 100 pounds of nitrate of soda and 200 pounds superphosphate is added. When the heads are beginning to develop, a third application of about 200 pounds of nitrate of soda to the acre is often desirable. For details consult Voorhees's "Fertilizers."

has increased in injuriousness from year to year. Frequently entire crops over considerable areas are completely destroyed.

Two or three generations of this maggot are indicated in the Northern States, and perhaps four or five in the South.

METHODS OF CONTROL.

Since this species also is a root-feeder, the remedies prescribed for the seed-corn maggot are applicable. In addition there are certain preventive and other measures for its destruction that have been found successful, their use being justified by the great value of cabbage plants.

Carbolic-acid emulsion, prepared as prescribed on page 2, and diluted about 35 times, is particularly applicable when this maggot occurs on radish and other plants than cabbage and cauliflower.

Hand picking, although laborious, has the merit of being effective, and is practiced with considerable success by extensive cabbage growers, although not practicable on radish and similar crops. It consists in pulling up the young cabbage or cauliflower plants, examining the roots for eggs and maggots, and either destroying the eggs and maggots by crushing with the hand or by washing the roots in a strong solution of soap and then replanting. In most cases the plants show no ill effects from this treatment after two or three weeks have elapsed. By looking closely, the minute white eggs may be seen about the stalks of young cabbages, and if the earth be raked away so as to expose the eggs to the sun these will dry up, thus preventing the maggots from hatching. Afterwards the plants should be hilled.

Methods of cultivation.—Experience shows that comparatively little is to be expected from various farming methods which are sometimes perfect safeguards against other insects. Whatever might be advised and found successful on one farm might, for one or more reasons, be found ineffective on another.

By keeping the soil well hilled around the plants the cabbage develops more roots, thus affording more food for the maggots and still leaving enough roots to strengthen the plant itself.

Crop rotation should be followed with any plants other than crucifers or onions. With these latter it is inadvisable, as the same atmospheric or other conditions which induce injury by the cabbage maggot seem to operate in increasing the numbers of the onion pest, which has a similar distribution.

Fall plowing is advisable.

Crop remnants of all crucifers, and particularly cabbage stumps, should be removed and destroyed, especially early in the season. Late in the fall a less number of maggots would be destroyed in this way, but it is always a desirable method for the protection of the crop against other pests which harbor in the old stalks or feed on the new leaves in early winter, to appear the next spring.

Gas lime, applied about each plant, has often been advised as a remedy, but those who have tried it are almost equally divided as to its efficacy. It is well worth further experiment where the gas lime can be obtained fresh without difficulty. It may frequently be had for the cost of carting.

The bisulphid of carbon treatment.—In case tarred paper cards, which will presently be described, or other preventive methods here given, are not employed, and the insects occur in great numbers at the roots of cabbage, bisulphid of carbon may be used. It should be applied below the root system with a special injector or syringe,¹ taking care that the application is not made directly to the plants, as it is very likely to kill them. A hole is made a little distance (3 or 4 inches) from the plant, and the injector inserted at an angle, as shown in fig. 2. After injecting the liquid the instrument should be withdrawn and the hole closed by packing it down with the foot. From a teaspoonful to a tablespoonful to each young plant, and a single application, is generally sufficient.

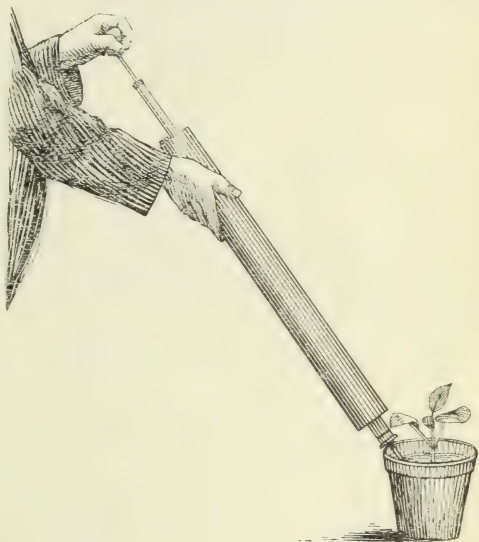


FIG. 2.—Bisulphid of carbon injector in use.

Tarred paper cards.—The use of disks or pads of tarred paper for the protection of cabbage against the oviposition of the fly was perfected in 1889 by Mr. W. H. Goff, who describes his cards and the manner of cutting them as follows:

The cards are cut in a hexagonal form (fig. 3), in order to better economize the material, and a thinner grade of tarred paper than the ordinary roofing felt is used, as it is not only cheaper, but being more flexible, the cards made from it are more readily placed about the plant without being torn.

The blade of the tool, which should be made by an expert blacksmith, is formed from a band of steel, bent in the form of a half hexagon, and then taking an acute angle, reaches nearly to the center, as shown in fig. 5. The part making the star-shaped cut is formed from a separate piece of steel, so attached to the handle as to make a close joint with the blade. The latter is beveled from the outside all around, so that by removing the part making the star-shaped cut the edge may be ground on a grindstone. It is important that the angles in the blade be made perfect, and that its outline represent an exact half hexagon.

¹ What is known as the McGowen injector, formerly manufactured at Ithaca, N. Y., but no longer for sale, has proved most successful.

To use the tool, place the tarred paper on the end of a section of a log or piece of timber and first cut the lower edge into notches, as indicated in fig. 4, using only one angle of the tool. Then commence at the left side, and place the blade as indicated by the dotted lines, and strike at the end of the handle with a light mallet, and a complete card is made. Continue in this manner across the paper. The first cut of every alternate course will make an imperfect card, and the last cut in any course may be imperfect, but the other cuts will make perfect cards if the tool is correctly made and properly used.

The cards should be placed about the plants at the time of transplanting. To place the card, bend it slightly, to open the slit, then slip it on the center, the stem entering the slit, after which spread the card out flat, and press the points formed by the star-shaped cut snugly around the stem.

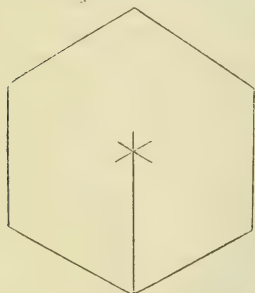


FIG. 3.—Tarred paper card in outline, one-half size (after Goff).

A Wisconsin grower protected 7,000 plants and secured a splendid crop, while unprotected plants nearby would have been a complete failure if the maggots had not been picked off by hand. Others have reported similar success. One reported having lost only 25 plants out of 10,000 to 15,000 that he protected with the cards, where ordinarily he would have lost from 75 to 90 per cent of the crop.

The tarred cards are applicable to cabbage and cauliflower only, but it is claimed by those who have employed them that they are cheaper, more practicable, and more efficient than anything else yet devised for preventing the ravages of the cabbage maggot. Success in using them is dependent upon their being properly applied, *to fit tightly*, so that the fly is unable to obtain access to the stem for the deposition of her eggs. Cards must be renewed and their use continued for each maggot year to be effective.¹

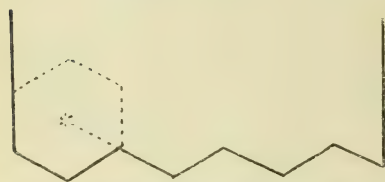


FIG. 4.—Showing how tool is used, dotted line indicating position of edge of tool (after Goff).



FIG. 5.—Tool for cutting cards, about one-fourth size (after Goff).

THE IMPORTED ONION MAGGOT.

(*Pegomya cepetorum* Meade.)²

The name "imported onion maggot" is used for this insect because there are other onion-feeding maggots in addition to the seed-corn

¹ A Wisconsin firm has used as many as 20,000 of these cards a year, and estimates the cost of material and labor at about \$1 for the protection of 1,000 plants. This shows its practicability on a large scale.

² This species is commonly referred to in literature as *Anthomyia* and *Phorbia ceparum* Bouché. According to Mr. Coquillett, it is difficult to decide, from the description of the adults, whether or not Bouché's and Meade's species are identical.

maggot. Its injury, which constitutes the most important drawback to the culture of onions, is accomplished by the consumption of the bulb, inducing subsequent decay of the affected portions and their very frequent destruction.

The fly and the maggot resemble preceding species, although their average size is a little larger. The length of the fly's body is about three-sixteenths and the wing expanse nearly three-eighths of an inch. The male is gray with black bristles and hairs; it has a white face with black hairs, and there are three dark lines on the body between the wings and a row of black spots on the abdomen. The female is a little the larger, and inclined to dark yellowish, with a pale yellowish face.

As in the case of the cabbage maggot, two or three generations are evidently the rule in the North.

REMEDIES.

The methods of control prescribed for the seed-corn maggot are frequently about all that are necessary for this species. In case of severe infestation the bisulphid of carbon treatment, discussed on page 5, as also other remedies advised for the cabbage maggot, are useful, with the exception of the tarred cards, which can not be conveniently nor economically used on onion. The flies are probably attracted to old onion beds and to crop remnants; hence clean field methods are advisable.

NOTE.—This circular has been prepared to facilitate correspondence, due to the fact that the three root-maggots mentioned herein have been extremely injurious during recent years. A monographic account, which has been of service in the preparation of this circular, was published in 1894 by Prof. M. V. Slingerland (Bul. 78, Cornell Univ. Agl. Exp. Sta., pp. 481-577). It is now out of print.

Approved:

JAMES WILSON,
Secretary.

WASHINGTON, D. C., *February 12, 1906.*

United States Department of Agriculture, BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist.

THE COTTONY MAPLE SCALE.

(*Pulvinaria innumerabilis* Rathvon.)

By J. G. SANDERS, Assistant.

The cottony maple scale (*Pulvinaria innumerabilis* Rathv.) at maturity is the most conspicuous scale insect indigenous to the United States, and has received much attention from entomologists and horticulturists on account of its occasional abundance. It was described in

1854 by Dr. S. S. Rathvon, of Lancaster, Pa., who gave the pest a very expressive and significant specific name. Since then over 60 articles and references concerning this species have appeared in entomological literature, besides hosts of others in newspapers and other periodicals. Of special worth is a monograph of the species, worked out in elaborate form by J. D. Putnam, which was published in the Proceedings of the Davenport (Iowa) Academy of Natural Sciences, p. 339 (1879).

More recently in Bulletin 22, new series, Division of Entomology, Dr. L. O. Howard published a thorough treatise on "The Two Most Abundant Pulvinarias on Maple," giving in detail the distribution, food plants, and life history of the cottony maple scale and the nearly related maple-leaf scale, illustrated by numerous figures of the various stages of each species.

Sporadic outbreaks of this scale insect in various parts of the United States have been reported from time to time for many years past, but in each case natural enemies have subsequently increased with sufficient rapidity to effectually check its progress. Recently many reports of its extreme abundance have come to us from the city of Chicago and

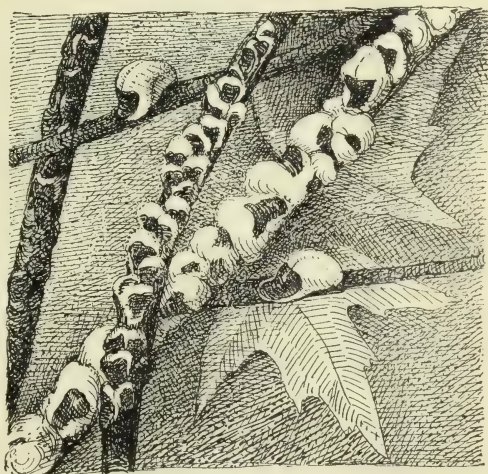


FIG. 1.—*Pulvinaria innumerabilis*: adult females in position on twigs, with egg sacs—natural size (from Howard).

vicinity, and from various sections of Illinois, Indiana, Wisconsin, and Iowa. It is interesting to note that most of the reports of serious injury by this insect come from those States or portions of States north of the fortieth parallel, where it seems to be attacked by fewer parasites than in the southern regions. A map of its distribution prepared by the author from locality cards shows that it is distinctively an Upper Austral zone species but occasionally reaches the Transition zone.

The cottony maple scale is classified in the soft, unarmored group (Non-Diaspinæ) of the family Coccidæ, and does not differ superficially from the Lecaniums, except in the formation of an ovisac by the female of the Pulvinaria. The male insect is a very small and delicate two-winged fly which develops its latter stage under a glassy test or covering and emerges late in August or early in September.

FOOD PLANTS.

The various species of maples, particularly the soft maple (*Acer saccharinum*), including the box-elder (*Acer negundo*), are the favorite food plants of this species. The writer has, however, found it on 47 different species of trees, shrubs, and vines, including various species of maple, oak, linden, elm, willow, poplar, beech, hawthorn, sycamore, locust, hackberry, osage-orange, mulberry, grape, poison-ivy, apple, pear, plum, peach, currant, gooseberry, rose, and Virginia creeper. It is possible that a very careful study will prove that all these infestations are not referable to one species, but that other species may be separated just as the maple-leaf Pulvinaria [*P. acericola* (Walsh and Riley)] and the osage-orange Pulvinaria [*P. maclura* ("Kenn.," Fitch)], once considered identical, were found to be distinct from the cottony maple scale.

HABITS AND LIFE HISTORY.

The large, white, flocculent masses, resembling popcorn fastened to the twigs, which appear on infested trees during the month of June, are the cottony (really waxy) ovisacs of the female, provided for the retention of the eggs after oviposition (fig. 1). These may contain as many as 1,500 minute, oval, pale reddish-yellow eggs.

The larvæ hatch at various dates from June 1 to August 15, depending on the latitude and exposure to the sun's rays. After remaining in the ovisac for a day or two, they swarm over the twigs, instinctively migrating toward the light, and settle on the leaves along the midribs and veins, always preferring the under surface (fig. 2, *e*). The larvæ on box-elder become active somewhat in advance of those on maple. This difference may be due to the food, but it must be remembered that the shade of the box-elder is less dense than that of the maple, and consequently the greater amount of heat and light may be the controlling factor. The male larvæ, when fully grown, assume a propupal stage from which they pass to the true pupal stage having a pinkish

hue. In a few days the winged males appear, but remain beneath the scale for two or three days before emerging. The females at this time have a few dorsal brownish markings and have undergone two molts. The males and females copulate in September, and soon afterward a small proportion of the females migrate to the twigs, where they insert their probosces and become fixed for the remainder of their existence, meanwhile changing from a greenish color to buff and finally brown, with a slightly tessellated waxy covering. In this condition the winter is passed (fig. 3).

When the sap begins to flow in the early spring the female grows rapidly, mainly because of the rapid development of great numbers of

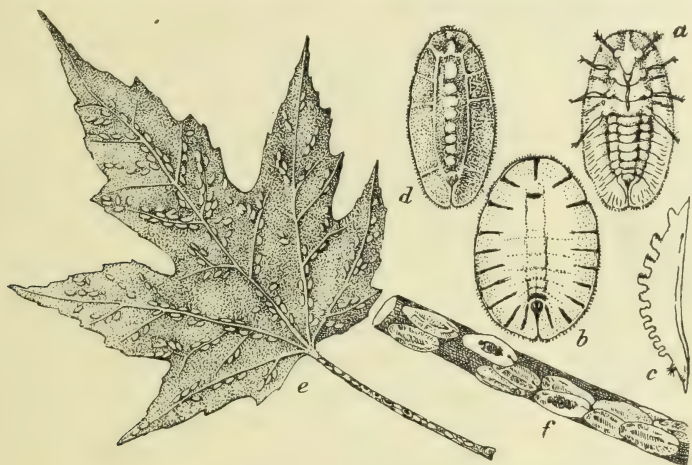


FIG. 2.—*Pulvinaria innumerabilis*: a, newly-hatched young; b, female, third stage, from above; c, same, from side; d, male, third stage; e, same, natural size, on leaf and petiole; f, same, enlarged, on leaf petiole showing two specimens parasitized—all greatly enlarged except e (from Howard).

eggs within the body. In May or early June the ovisac begins to form from the fine waxy threads exuded from the posterior spinnerets, pushing backward and upward until the body of the female is almost vertical to the twig. Meanwhile the ovisac is gradually being filled with eggs, which hatch and undergo all the changes mentioned above. Thus, fortunately, there is but a single brood each year.

PARASITES AND PREDACEOUS ENEMIES.

Notwithstanding the extreme prolificacy of this insect, it is usually held in check by its many natural enemies. Doctor Howard has observed the English sparrow apparently feeding upon the full-grown scales. The twice-stabbed ladybird (*Chilocorus bivulnerus* Muls.) is a common enemy of this as of other scale insects, particularly in its early stages. The smaller similarly marked *Hyperaspis binotata* Say (fig. 4) and *H. signata* Melsh. are also valuable enemies of this species. The writer found in the severely infested parks and cemeteries

in Chicago that the egg-contents of 80 to 85 per cent of the cottony ovisacs had been destroyed by the white mealy larvæ of *Hyperaspis*. These larvæ enter and devour the entire contents of one ovisac after another without destroying its form, so that only an examination will reveal the empty ones.

The predaceous caterpillar of *Lætilia coccidivora* Comst. has been an efficient ally in controlling the pest in the vicinity of Washington, D. C. It is particularly effective where the cottony masses are in close proximity, because of its habit of eating its way through the masses, spinning a strong web about itself, and forming a gallery as it progresses. The caterpillar is very active and moves about freely within its web.

Several specimens of *Leucopis nigricornis* Egger, a common dipterous parasite of aphides, were reared from cottony maple scale collected in Chicago, Ill., on July 21, 1905, by the writer, and from other specimens sent to the Bureau from Crystal Lake, Ill. This parasite is considered to be a European species, and although aphides seem to be its favorite host, it is occasionally reared from nondiaspine Coccidæ.



FIG. 3.—*Pulvinaria innumerabilis*: gravid female, greatly enlarged, before commencing to secrete egg sac in the spring (from Howard).

Several species of chalcid flies (Chalcidoidea) are truly parasitic upon the cottony maple scale as well as upon others of the Lecaniinæ. There is no doubt that many more *Pulvinarias* are killed by these interesting little fellows than by all other enemies. *Coccophagus lecanii* Fitch, *C. flavoscutellum* Ashm., *Atropates collinsi* How., *Aphycus pulvinariæ* How., *Comys fusca* How., and *Eunotus lividus* Ashm. have been reared from the cottony maple scale.

REMEDIES.

In dealing with an infestation by the cottony maple scale, the most important matter to be considered in each case is the advisability of artificial means of control under the existing conditions. The natural enemies of this pest have done and are still doing such effective work in its control, that it is a question whether remedies should be applied when the infestation is not serious. Nature always maintains a balance, and this pest can not be in the ascendancy for any great length of time. On the contrary its parasites will eventually multiply so rapidly as to completely check its progress, and it may even narrowly escape extermination.

Insecticides applied for a pest always kill its parasites and oftentimes predaceous enemies are also destroyed. Hundreds of larvæ of *Hyperaspis binotata* were found to have been destroyed by a summer treatment with kerosene emulsion for the cottony maple scale in parks

of Chicago, and no doubt thousands of the minute chalcids were killed, as they were found quite plentifully on unsprayed trees.

If it is necessary to resort to artificial means of control, as seems to be the case in some sections, the spraying should be delayed until fall or winter, when the *Hyperaspis* is hibernating at the bases of the trees among lichens, moss or dried grass. Care should be exercised in the use of spray, and the bases of trees should be covered with canvas or other suitable material to prevent the spray from running down the tree-trunks and collecting at their bases.

WINTER TREATMENT.

When the trees have become dormant, after the falling of the leaves, they can be trimmed and thoroughly sprayed with a strong kerosene emulsion, which will kill every scale reached by the spray, without injury to the trees. Scarcely one-fourth the quantity of emulsion is required to spray a tree in winter condition that is necessary when a tree is covered with dense foliage and both sides of the leaves must be reached with the spray. Some excellent results have been obtained by Mr. S. Arthur Johnson¹ in experiments against this pest in Denver, Colo. He found that kerosene emulsion 25 per cent or more in strength or whale-oil soap at the rate of 1 pound to 1 gallon of water was very effective, apparently killing all scales which received the spray.

SUMMER TREATMENT.

Kerosene emulsion of not more than 10 to 12 per cent of oil can be thoroughly applied with safety to maple trees, but the tips and margins of the leaves may be injured even at this strength. Box-elder will be almost defoliated with a 12 to 15 per cent solution. Less than a 10 per cent emulsion will be of little value against the young unless they have recently hatched. Since the hatching period may extend over six or eight weeks, it will be seen that more than one spraying will be necessary to insure success, and, coupled with the fact that it is a very difficult and disagreeable task to thoroughly spray a tree in foliage, the winter treatment will be found more satisfactory in every way. And at that season the larvæ of predaceous beetles would not be destroyed.

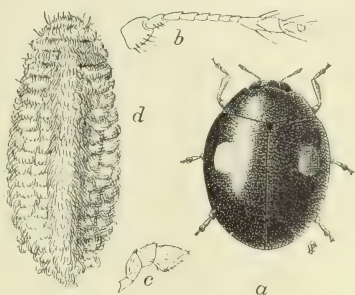


FIG. 4.—*Hyperaspis binotata*: a, adult; b, antenna; c, palpus; d, larva—enlarged (original).

¹ 1905: Bul. 52, U. S. Dept. Agr., Bureau of Entomology, pp. 85-88.

KEROSENE EMULSION.

Stock solution (66 per cent oil).

Kerosene (coal-oil, lamp-oil) -----	gallons--	2
Whale-oil or laundry soap (or 1 quart soft soap) -----	pound--	$\frac{1}{2}$
Water -----	gallon--	1

Dissolve the soap in boiling water, *then remove from the fire*, add the kerosene immediately and thoroughly agitate the mixture until a creamy solution is obtained. This can be done by pouring the mixture into the tank of a spray-pump and pumping the liquid through the nozzle back into the tank. This is a stock solution, which must be diluted before using. In order to make a 10 per cent emulsion, add to each gallon of the stock solution about 6 gallons of water and agitate thoroughly before using. For a 30 per cent solution add to each gallon of the stock solution $1\frac{1}{2}$ gallons of water and agitate thoroughly. This strength will kill a large percentage of the hibernating females, without injury to the trees.

If a good naphtha soap can be obtained, the preparation of the emulsion will be simplified. It will be unnecessary to heat the solution, since the kerosene will combine readily with the naphtha and soap and form a perfect, cold, milky-white emulsion when the mixture is thoroughly agitated. If naphtha soap is used, double the amount called for by the formula, and emulsify in soft (rain) water.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *September 7, 1905.*

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist.

THE COTTON RED SPIDER.*(Tetranychus gloveri Bks.)*By E. S. G. TITUS, *Special Field Agent.*

Injury to cotton by the red spider, or rust-mite as it is also called, has been quite prevalent in some sections of the cotton-growing area of this country during the past two years. The cause of the injury is a minute yellowish-red mite which feeds on the cotton plant, principally on the under sides of the leaves, but at times attacking all parts of the plant. The mites usually appear early in the season, but do little appreciable damage until midsummer or later. The injuries rarely become serious unless accompanied by long-continued dry weather; in such an event the multiplication of the mites is very rapid, and the consequent injuries are often sufficient to kill the plants.

The early attacks of this mite are quite characteristic; the leaves presenting on the upper side near the base a scarlet appearance, which, occurring at first between the larger ribs, gradually spreads over the leaf as the mites multiply, then dies out and is replaced by a dirty yellow, the leaf finally shriveling and falling to the ground. Larger and older leaves show the effect of the attack before younger leaves.

The mites feed on the under side of the leaves, protected by a loose, irregular web stretching at first from vein to vein, but later attached at any point and in cases of severe injury sometimes covering both sides of the leaf.

Rarely have the red spiders been found feeding on the upper side of the leaves, and then only when they are protected or shaded by the leaves above, or when a leaf has begun to curl from their injuries.

When present in considerable numbers almost all parts of the plant may be attacked—flowers, squares, bolls, and stems. Severely injured plants lose most of their leaves, flowers, and younger forms; quite often only the young unfolding leaves at the tips of the branches are left green.

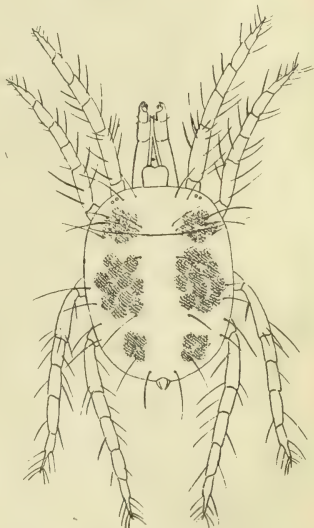


FIG. 1.—*Tetranychus gloveri*: Adult—much enlarged (original).

This species was first described by Mr. Nathan Banks, of the Bureau of Entomology, in 1900,¹ from specimens collected on cotton by Prof. H. A. Morgan, of Baton Rouge, La. In 1893-94 it had caused considerable damage at Baton Rouge.² The pest is very probably distributed throughout the entire cotton-growing area of the South, although during late years its occurrence in injurious numbers had not been reported until the summer of 1903, when it caused considerable damage to cotton in South Carolina and Georgia. In 1904 red spider was found on several plantations near Batesburg and at other points in South Carolina. During the summer of 1905 many reports of its occurrence were received from points in North Carolina, South Carolina, Georgia, and Alabama, and the writer found it in injurious numbers at several localities in these States.

The first published records of the species appear to be those by Townend Glover, in an article on Cotton Insects published in 1855,³ in which he gives a description of the mite and its injuries to cotton under the name of "The Red Spider. *Acarus*?" and in 1878,⁴ in his Cotton Insects under the name of "cotton rust," again referring the injury to an "*acarus*." He recommends powdered sulphur or sulphur mixed with slaking lime as remedies.

LIFE HISTORY.

When first deposited the eggs appear as minute translucent pearl-like objects, found only by careful observance on the threads of the web, on the plant hairs beneath it, and more rarely on the epidermis of the leaf itself. As they mature they grow darker, becoming quite opaque, with more or less of a red or greenish tinge.

The eggs hatch in from three to five days during hot, dry weather, and the young mites commence feeding almost immediately. At this early stage they have but six legs and but few red markings. They reach maturity in from ten to fourteen days after hatching. At maturity the mites vary from specimens with very small red spots to those that are all red on the dorsum and have the legs lightly marked with red dots. The mature mites are eight-legged. According to Mr. Banks, the adults of this species are distinguished by the following characteristics: Bristles of body not arising from tubercles; tarsus with but one claw, which is strongly bent near its middle and four-cleft beyond; three fingers on the tip of the thumb, which is not as long as the claw, the middle finger largest from side view; mandibular plate broad, sides concave near tip and apex truncate or slightly broadly emarginate (fig. 2).

¹ 1900: Banks, Tech. Series 8, Bur. Ent., Dept. Agric., pp. 76-77, fig. 15.

² 1897: Morgan, Bul. 48, La. Agric. Exp. Sta., pp. 130-135.

³ 1855: Glover, U. S. Patent Office Rept., p. 79, Pl. VI, fig. 7.

⁴ 1878: Glover, Cotton Insects, plate 3.

Where and in what stage the mites hibernate is not known, but it is probable that the early spring generations live upon some other than the cotton plant, probably upon various weeds and in some sections on water-oak.

MEANS OF DISTRIBUTION.

The distribution of mites over a field may be accomplished in several ways. The minute mites cling to almost any substance that brushes so forcibly against them as to remove them from the plant; and when brought in contact with plants farther along the row, or elsewhere, they will be brushed off and cling to them. The mites have been taken from several insects, such as grasshoppers and small Hemiptera, found visiting the cotton plants. Probably the most common means of distribution occurs during the cultivation of the crop. The hoe gangs and the cultivators rapidly and thoroughly scatter the mites over the field. Hoe gangs will spread them broadcast—down the rows during their daily labor, and across the field when they leave it, since they usually go by the shortest route. The effect of distribution along the rows can be most easily traced in terraced cotton.

The writer in 1904 and 1905 made short trips to South Carolina to study this pest. In several instances it was noticed that from a point on the margin of a field where there were growing large poke-berry plants (*Phytolacca decandra*) the infestation by red spider had spread over a fan-shaped area of the adjoining cotton. Other places

were seen where this same weed occurred on terraces, and here also the mites were present in considerable numbers on adjoining cotton. At that time of the year (July and August) these weeds, as well as the cocklebur (*Xanthium* spp.), showed the effect of red spider work. The mites were too scarce, however, for positive identification. Specimens occurring on corn, cowpeas, and beans were identified by Mr. Banks as the cotton red spider. These plants all showed appreciable injury by the pest. Especially was this true of one field of corn that was planted in a cotton field, the rows alternating.

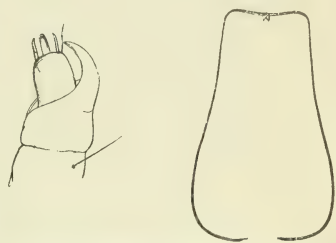


FIG. 2.—*Tetranychus gloveri*: Palpus and mandibular plate—enlarged (from Banks).

METHODS OF CONTROL.

Enemies.—No parasites have yet been reported as living in this red spider. However, there are several species of predaceous insects that prey upon the mites and their eggs. Among these are larvæ of Chrysopas or lacewings, and lady-beetle larvæ and adults. One species of Pentilia, a minute black lady-beetle, is very destructive to the red spider; this and other Coccinellids (lady-beetles) were noticed feeding on the mites at several places visited in 1905.

Cultural methods.—These are: (1) Rotation of crops. (2) Destruction of cotton stalks, weeds, and grasses in the infested fields after cotton picking is over in the fall, by pulling and burning where possible. (3) Deep fall or winter plowing, taking care to thoroughly turn under all the vegetation. (4) Burning off or otherwise destroying the weeds, grasses, and rubbish on the terrace edges, ditches, and borders of the field. (5) *Keeping down all weeds and grasses in the early spring.*

Remedial measures.—A careful outlook should be kept on the young cotton in the early spring, and at the first indication of injury prompt action should be taken. If, when first noticed, there are but few infested plants, these may be pulled and burned, care being taken not to distribute the mites to the surrounding cotton during the operation. The cotton surrounding the infested place should then be thoroughly sprayed with one of the mixtures described below, preferably one containing sulphur. Spray the plants thoroughly, taking especial care to cover the *under sides of the leaves* and the stems and branches.

If a large area is infested when first noticed, or if it should be found desirable to spray whole fields, a barrel or tank outfit should be used. The pump should have no copper about it, a brass cylinder being preferable. With one man to pump and two lines of hose, very rapid work can be done. Sufficient hose should be used to allow free movement around the plants being sprayed. It will be well to have an iron pipe attached to the hose with the outer end bent upward and threaded for the attachment of the nozzle. The pipe should be long enough for this elbow to reach the ground when the man doing the spraying is standing upright. Use a nozzle distributing a fine spray. By this means the under sides of the leaves can be easily sprayed by simply moving the pipe up and down through the plant.

Among the many remedies that have been used against red spiders on various occasions the *sulphur mixtures* stand foremost. *Water*, *kerosene emulsion*, and *soap washes* will also kill many of the mites and some of the eggs. There will, however, be some eggs left to hatch, and these sprays leave nothing on the leaf to kill the young freshly hatched mites. No spray can be expected to reach all the mites or their eggs, but the sulphur preparations, when properly prepared and applied, adhere to the leaves, and there will be enough sulphur left on the leaf to destroy most of the young mites that appear later.

INSECTICIDE FORMULÆ.

Sulphur.—Ordinary powdered sulphur can be used dry, blown from one of the powder guns manufactured for dry sprays. It may also be used mixed with flour, road dust, or plaster of paris.

Lime-sulphur.—Into slaking lime dissolve an equal amount of powdered sulphur. If only a small quantity is to be made, the heat gener-

ated by the slaking will be sufficient to cause the sulphur and lime to unite. If considerable quantities are being prepared, it will be well to slake the lime in boiling water in an *iron kettle* (never in copper) and keep the mixture boiling for a short time after the sulphur has become well incorporated. The mixture should be constantly stirred until it is smooth and even. Five pounds of sulphur and 5 pounds of lime will make, after diluting, 100 gallons of spray mixture. This may be used stronger, if desirable, but care must be taken not to injure the plants.

Lye-sulphur.—"Mix 20 pounds flowers of sulphur into a paste with cold water, add 10 pounds of pulverized caustic soda (98 per cent). The dissolving lye will liquefy the sulphur and boil. Water must be added from time to time to prevent burning until a concentrated solution of 20 gallons has been obtained. Two gallons of this is sufficient for 50 gallons of spray, giving a strength of 2 pounds of sulphur and 1 of lye to 50 gallons of water."¹ This has been successfully used against the orange red spider in California.

Kerosene emulsion.—Dissolve 1 pound hard or 1 quart soft soap in 1 gallon hot water, add 1 gallon coal oil, and emulsify. The most thorough and feasible method is to pump the spray mixture back upon itself until it is thoroughly emulsified. Dilute to 10 gallons and use as soon as possible. With the recent advent of a certain naphtha soap which will emulsify without heating, kerosene emulsion can be readily made in the field with cold water.

Water.—This treatment is quite commonly used by greenhouse men in fighting red spider in propagation houses, conservatories, and parks. The water is driven onto the plants in a fine spray with considerable force.

¹ 1903: Marlatt, Farmers' Bul. 172, U. S. Dept. Agr., p. 41.

Approved:

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *October 30, 1905.*

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE JOINT-WORM.

(Isosoma tritici Fitch.)

By F. M. WEBSTER,

In Charge of Cereal and Forage Plant Insect Investigations.

Since the first known serious outbreak of the joint-worm (*Isosoma tritici* Fitch), which occurred in the wheat fields about Charlottesville and Gordonsville, Va., during the years 1848 to 1854, this insect has been reported at irregular intervals and from widely separated localities. While it is known to occur sparingly over most of the wheat-growing sections of both the United States and Canada, and probably does more damage than has generally been attributed to it, its reappearance in the wheat fields of Indiana, Michigan, Ohio, Pennsylvania,



FIG. 1.—*Isosoma tritici*: Adult of the joint-worm. Much enlarged (from Howard).

West Virginia, Virginia, Maryland, and Kansas in 1904, and in still greater numbers in 1905, serves to bring it again to notice. In 1904 some fields of wheat in eastern Ohio were so badly damaged that they were not harvested, and in 1905 a serious outbreak in northeastern Indiana so discouraged some farmers that they questioned the advisability of putting in a crop of wheat at all. In southwestern Virginia the pest was even more injurious in 1905 than it was the previous year. The pest was also very destructive in western Ohio and eastern Indiana during the spring of 1908.

DESCRIPTION OF THE PEST.

The fully developed insect, somewhat resembling a small, winged black ant, is clearly shown, enlarged, in figure 1, its natural size being indicated by a line at the right. The color is black, with joints of legs and feet yellow. The larva or grub is whitish, with brown jaws, the length being about the same as that of the adult, and the form much like that shown in figure 2, which represents the larva of a nearly related species.

LIFE HISTORY.

The insect may be found in wheat stems, in its various stages of development, throughout the year. It lives through the winter as a larva

or grub in cells formed in the stems prior to the ripening of the grain, the adult emerging therefrom in April or May, according to latitude, or some time after the young grain has thrown up stems and several joints have become exposed. The female, using her slender, pointed ovipositor, places her eggs in the stems. The exact position assumed is shown in figure 3,

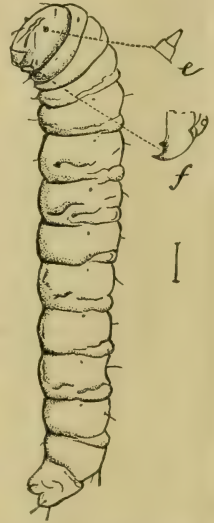


FIG. 2.—*Isosoma grande*: Larva of the wheat-straw worm; e, antenna; f, jaw. Line at right indicates natural length. (After Riley.)



FIG. 3.—Female *Isosoma* in act of depositing egg in stem. About life size (author's illustration).

from a photograph from life by Mr. G. I. Reeves. The eggs hatch and the young grubs, forming cells, feed in the walls of the stem, reaching their maximum growth by the time the straw becomes fully hardened and ripe. Wintering in the larval state, they pass a short pupal stage and emerge as adults in the spring. While there are both males and females among these insects,

Mr. Phillips of this Bureau has, during two successive years, found that unfertilized females will deposit eggs and that these eggs will hatch out larvæ which develop to adult insects. It is probable, however, that these adults will be found to be largely or all males.

EFFECT ON THE STRAW.

The effect on the straw of the work of the joint-worm is exceedingly variable. Sometimes a distortion occurs like that illustrated in figure 4; at other times the straw is bent or twisted in almost every conceivable shape; again, there will be no enlargement of the straw whatever; or there may be large galls or excrescences, as it were, bursting out of the base of the sheath at one side, some of these abnormal growths having pseudo-rootlets extending downward from their lower extremity. Sometimes the straw will make about normal growth and the hardened sections will be restricted to an inch or thereabouts just above the lower joints; and, again, the growth will not exceed 3 or 4 inches, often not heading at all, or with aborted head and with the straw galled or hardened to the base of the head. In some cases there is no outward indication of attack whatever, the affected part being wholly inclosed in the sheath, and when this last is removed the presence of the cells is indicated only by a slight discoloration, and frequently by a few small, more or less irregular, elevated ridges.

In thrashing the grain the hardened portions of the straw, as shown in figure 5, break up into pieces of from half an inch to an inch or more



FIG. 4.—One effect of the joint-worm in wheat straw. (Author's illustration.)

in length, many of which do not go over with the straw and chaff, but remain with the grain. The presence of these bits of broken straw in the grain is frequently the first evidence the farmer has seen of the occurrence of the pest in his fields. Millers and elevator men note them also, and in sections where the pest has committed serious depredations several bushels of these hardened bits of straw are found after each day's cleaning of the grain.

EFFECTS ON THE KERNEL.

The wheat heads from infested stems are foreshortened, and the kernels thereby necessarily reduced in both size and number, and in case of severe attack they become shrunk.

NATURAL ENEMIES.

Natural enemies of the joint-worm are quite numerous, and most of them have the advantage of being double-brooded, whereas the joint-worm has but one generation annually.

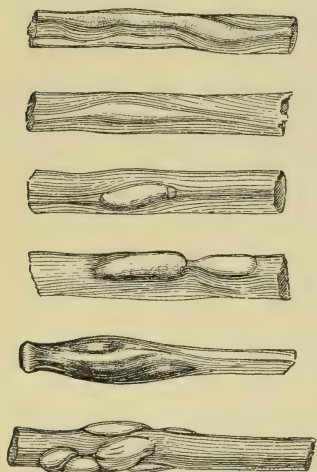


FIG. 5.—Bits of hardened straw remaining with the grain after thrashing. (Author's illustration.)

Among the most efficient of these are two rather common species of insects. One of these, almost as big as the *Isosoma* itself, with dull metallic thorax and yellow abdomen and with long ovipositor, is *Ditropinotus aureoviridis* Crawford, and the other, smaller, darker colored, and slender, also somewhat resembling an *Isosoma*, is *Eupelmus allynii* French. The writer reared also another species in Ohio, *Websterellus tritici* Ashm., which has similar habits.

A somewhat similar insect with metallic body and yellow abdomen, *Stictonotus isosomatis* Riley, is very efficient in destroying the larvæ in the straw. *Homoporus* (*Semiotellus*) *chalcidiphagus* Walsh and Riley, and beyond a doubt other chalcidoids, are also instrumental in holding the pest in check. These are all small four-winged flies, and a number of additional, undescribed forms have been discovered.

The larva of a small, slender, black and yellow carabid beetle (*Leptotrachelus dorsalis* Fab.) crawls up, descends into the stubble, and devours the *Isosoma* larvæ, but unfortunately its sense of taste seems to be too obtuse to allow it to confine itself strictly to *Isosoma*, and as a consequence it devours parasites as well as host. A mite, *Pediculoides* (*Heteropus*) *ventricosus* Newp., is also an enemy, gaining access to the larvæ precisely as does the beetle larva previously mentioned.

PREVENTIVE MEASURES.

There are no known remedies for the joint-worm, but there are several preventive measures that are not impracticable and are reasonably efficient.

In the midst of the outbreak in Virginia, previously mentioned, a "Joint-worm Convention" was held at Warrenton, in that State, to devise means for controlling this pest. This body recommended a better system of farming, the use of guano and other fertilizers to promote a rapid growth and an early ripening of the grain, and the burning of the stubble, all of which are as advisable to-day as they were at that time. The most serious ravages are observed on thin or impoverished soils, especially along the margins of the fields infested. Anything, then, that tends to add vigor to the young growing grain will constitute a preventive measure. Burning the stubble, where this is practicable, is, of course, most efficacious, but over the larger portion of the territory ravaged by this pest it is customary to seed with grass after wheat, and under this condition burning over the stubble field is impossible. Such fields should be raked over with an ordinary hay rake, and the loosened stubble removed and burned before the adults have emerged in the spring. If, however, the grain is cut low at harvest, and the straw passed through the stables as bedding for stock during the winter, thus becoming saturated by liquids and more or less thoroughly composted, the treatment would seem sufficient to destroy the *Isosoma* larvæ so that few, if any, would develop adults the following spring. In case of bedding for horses, it seems quite probable that if any larvæ at all survived the thrashing machine, the heat from the decomposing manure would develop them prematurely. However, there has been no experimentation exactly along these lines, and according to a press bulletin^a by Prof. R. H. Pettit, of the Michigan Agricultural College, serious injuries have followed the year after application and plowing under of barnyard manure in the fall before the wheat was sown. In this case the manure would necessarily be fresh and the bedding of straw of the same season's growth, otherwise the adults would have already emerged. This would be a proposition quite different from that of allowing the stable manure to accumulate during the winter and applying it in the spring elsewhere than to the wheat fields, or even of applying it to wheat fields before plowing, months after the larvæ surviving the effects of the stable had developed and escaped. The one might destroy all or nearly all larvæ in the straw, and the survivors would emerge about the stables or in the barnyard; while the other method, simply to take the straw with the living larvæ present from an old field, move it

^a Mich. Agr. Col. Exp. Sta., Press Bull. No. 15. The Wheat Joint-Worm.

through the stable, cart it out on a new field, and plow it under, is one that the farmer should evidently be careful to avoid.

Exactly in this connection, an assistant, Mr. Charles N. Ainslie, while waiting between trains in the city of St. Louis, Mo., found at the corner of Sixteenth and Locust streets a pile of bricks to be used in the erection of a building. These bricks were stamped "Massillon, Ohio," and were packed in straw which the chief contractor stated came with the bricks from Ohio. This straw contained larvæ of this species which later on transformed to adults, but the latter did not emerge from the straw.

In the past it has always been thought necessary, as a precautionary measure, to burn the infested bits of hardened straw that break up

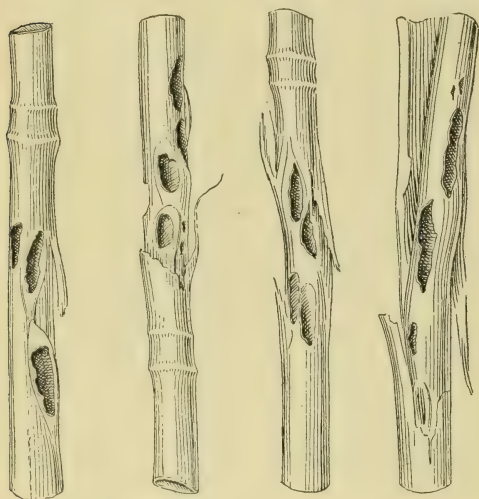


FIG. 6.—Wheat straws injured by the joint-worm (*Isosoma tritici*), from which the joint-worms have been removed by some beneficial animal, perhaps the short-tail shrew (*Blarina brevicauda*). (Author's illustration.)

in thrashing the wheat, many being carried out with the grain instead of going over in the straw. Several experiments in rearing adults from large numbers of these broken bits of straw (fig. 5), collected about elevators and thrashing machines, has shown that almost all of the larvæ of both *Isosoma* and parasites are killed, probably by the concussion of the cylinder of the thrasher. In some cases we have been able to verify these experiments by collections of stubble from fields in the vicinity of these elevators. So far as we have gone into the investigation everything indicates that the

danger from these broken bits of hardened straw, or even from the straw itself, is of too little importance to be worth consideration. Prof. R. H. Pettit, of the Michigan Agricultural College, and Mr. W. J. Phillips, of this Bureau, in 1906, found in northern Indiana great numbers of straws affected by the joint-worm, where the enveloping sheath had been torn away, the galls formed by the larvæ deftly eaten away, and the joint-worms missing. In no case was the entire gall gnawed away, but just enough of the walls immediately over the larva to make possible the removal of the latter (fig. 6). While we have not been able to get definite information as to the identity of this decidedly beneficial animal, suspicion seems to point to the short-tail shrew (*Blarina*

brevicauda) as the species to which credit should be given, and probably much of the work is done while the grain is in shock.

Rotation of crops is advantageous, because it necessitates the migration of adults from one field to another, and if this takes place in stormy weather or during high winds, many of the migrants will be killed or blown astray. It is easily seen that where infested straw is applied to a new field prior to sowing to wheat, this migration of adults would not be made necessary.

The sowing of early ripening varieties is also beneficial.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *July 16, 1908.*

[Cir. 66]

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist.

THE CLOVER ROOT-BORER.

(*Hylastinus obscurus* Marsham.)

By F. M. WEBSTER,

In Charge of Cereal and Forage-plant Insect Investigations.

This insect is not a native of America, but has been introduced from Europe and has established itself in the fields of red clover in some sections of the eastern United States. It frequently commits serious depredations by burrowing in the roots, thereby destroying them. It has long been known in Europe as a clover pest, Eichhoff¹ giving its distribution as Germany, Austria, France, England, and the Canary Islands. Other European entomologists have also written of its occurrence, and, according to Bach, it infested large fields of clover near Odenbach, Germany, in 1803, an occurrence evidently coincident with its description by Marsham in 1802.

While it did not come to notice in America as a pest until about 1878, when it was found in destructive abundance in central New York, it probably occurred in the country long prior to that date. Dr. Hopkins, who is making a special study of this group of beetles, viz, the Scolytidæ, has shown the writer a specimen, from the collection of the late Dr. Fitch, with a New York label attached to the pin, referring to a note which he has been unable to find. In all probability, however, this specimen antedates the discovery of the insect by Riley in 1878. Besides, owing to the obscure habits of the pest, it is more than likely that it was injurious to clover even prior to this date without, however, having been detected by farmers. Even at present, in the Middle West, where it is most destructive, it has attracted little attention, the effects of its ravages being usually attributed to adverse meteorological conditions. The pest seems to have spread much more rapidly westward, as it probably occurs nearly to the Mississippi River; but it has attracted no attention along the Atlantic coast south of Pennsylvania. In that State, however, the writer recently found it abundant

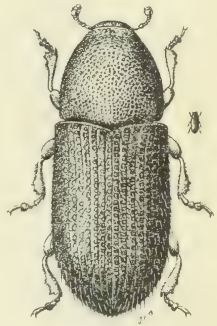


FIG. 1.—*Hylastinus obscurus*: Adult insect—natural size at right (original).

¹ Die Europäischen Borkenkäfer, p. 97, 1881.

around Chambersburg, but not disastrously so. It has not been reported at all from the vicinity of Washington, D. C. It is certainly not seriously injurious in the New England States at the present time, and Dr. Fletcher reports a similar state of affairs in Ontario, Canada, while in Ohio, West Virginia, Indiana, and southern Michigan it is becoming more and more destructive.

DESCRIPTION OF THE INSECT.

The fully developed insect is a small, dark-brown, hard-bodied beetle, shown enlarged in figure 1.



FIG. 2.—*Hylastinus obscurus*:
Larva or grub—much enlarged (original).

The larva, or grub, shown enlarged in figure 2, is about an eighth of an inch long, dingy white, with honey-yellow head and brown jaws.

The pupa (fig. 3), is even smaller than the larva, also dingy white, with two minute spinous projections on the top of the head and two somewhat larger ones at the anal extremity.

The eggs are elliptical, white, and minute, yet large enough to be seen with the unaided eye.

LIFE HISTORY.

There is certainly but one generation annually, though this appears to be long drawn out, and

scattering individual larvæ and pupæ may be found throughout every month of the year. The finding of eggs as late as September 18 has been reported from Michigan. As a rule, however, the insects pass the winter in the adult stage (fig. 1) within the roots where they developed. During May they abandon the old roots and seek out fresh plants or fields in which to lay their eggs. The eggs are mostly deposited between the middle of May and June 20. The female gouges out a shallow cavity, more often in the crown of the plant, sometimes at the sides of the root even 2 or 3 inches below the crown, and in this places, singly, but not far separated, about half a dozen pale, whitish, elliptical, very minute eggs. These hatch in about a week, and the larvæ (fig. 2) for a time feed in the excavation made by the mother, but soon burrow downward into the root, and before the first of August the majority of them have become fully grown and passed into the pupal stage (fig. 3). By October nearly all have become fully developed beetles, but they make no attempt to leave the plant until the following spring. Bach states that the adults fly at Omegnen in March and April, while Eichhoff has observed them near Mülhausen, swarming during the warm afternoons about the middle of



FIG. 3.—*Hylastinus obscurus*: Pupa—much enlarged (original).

June; but these observations were all made in different parts of Europe. In our own country, in Ohio, the adults are abroad and have been swept from clover fields early in May; but no swarming of the beetles has been observed, though it is clear that they may migrate about that time of the year.

FOOD PLANTS.

In Europe, besides red clover and alfalfa, the species is known to attack *Spartinum scopanum* and *Ononis natrix*. In America it has so far been especially destructive to red clover (*Trifolium pratensis*), yet with the recently increasing interest in the growing of alfalfa (*Medicago sativa*) in the Northern States it may be expected to become destructive to that crop also. Besides, it is known to attack mammoth clover (*Trifolium medium*) and alsike (*T. hybridum*). The fact that it also injures the garden pea will be very suggestive to growers of peas for canneries, and indicates the undesirability of sowing peas early in the season on ground that has recently been in these clovers or lying adjacent to the infested clover fields. Late-sown peas, however, would probably not become sufficiently large to invite attack until after the beetles had appeared and gone.

METHOD OF ATTACKING RED CLOVER.

The insect's method of attack is well illustrated by figure 4, showing a clover root split in two, exposing the excavations. In cases of extreme abundance, however, almost the entire main root, except the bark, is eaten out, the substance being displaced by excreta, and the dead top either becomes detached of itself or is easily broken off if one attempts to pull up the plant. It will be observed at once that until the roots have attained sufficient dimensions it will be impossible for the insect to attack them. Over the territory where red clover is grown in this country the seed is sown either during late winter or spring; and during the first year the roots of the plants have not yet attained sufficient size to accommodate the insects at the time the latter are, with the exception, perhaps, of a few belated individuals, abroad and depositing their eggs; and thus the plants are almost, if not, indeed, entirely, exempt from attack the first year. Hence it is not until the summer of the second year that they are destroyed. This has led European entomolo-



FIG. 4.—Clover root, showing work of *Hylastinus obscurus*—slightly enlarged (original).

gists to believe that, like many others of the Scolytidæ, the insect does not attack the plant until the latter has become weakened by age or is diseased. But, in this country, at least, this can not be true, for the reasons just given. It is not improbable, however, that, as between two plants with roots of the requisite size, an unhealthy one would be preferred by the beetles rather than one in a thoroughly vigorous condition. But, as yet, there have been no observations tending to verify this hypothesis. A diseased clover root, or one that has begun to decline from effects of age, is first affected at the heart; and, as will be observed from figure 4, this is the part first attacked by the root-borer.

EFFECT UPON THE PLANT.

While an infested clover plant sooner or later succumbs to an attack by this insect, life may be lengthened or shortened by meteorological conditions. Thus, if the spring or early summer is very dry, the plants begin to die in patches late in June, as soon as the hay crop is removed; but if there is much rain during this period, the weakened plants may continue to live until winter, dying out before spring. In either case the farmer is likely to be misled and to attribute the loss to the weather. The summer of 1905 was not a dry one. Copious rains fell with sufficient frequency to enable all but the most seriously affected plants to survive. A prominent seedsman of Indiana, who was much among clover fields, thus described the situation in October:

In driving around this year and examining clover fields, we have found that several fields which apparently should have produced an immense amount of seed, or at least, say, 3 or 4 bushels to the acre, * * * did not shake out anything. We pulled up some plants and discovered that the plant broke off at the crown; or if any of the root did come with it, it was small and decayed. On close investigation we discovered a little white worm which seemed to be in abundance and working amongst the roots. We noticed this in a number of fields and have been wondering what it was. We have also had samples of clover plants from other sections of Indiana showing these conditions, and almost invariably the yield of such fields was less than a bushel per acre, and in many instances hulling was abandoned and the huller taken out of the field.

NATURAL ENEMIES.

While Dr. Riley found the larva of one of the common soldier beetles, probably *Telephorus bilineatus*, attacking the larvæ of the borer, and although it probably has other enemies, both among insects and birds, these have so far proven of little economic importance.

PREVENTIVE MEASURES.

The only preventive measure yet tried that gives any promise of success is summer fallowing as soon as the hay crop is removed.

At this time the young are in an immature state and, if deprived of food, must perish. They can not migrate from one clover root to another, and, if the meadow is now broken up, throwing the roots up

to the hot sun and winds, these wither and dry, thus no longer supplying the necessary sustenance, at this time so imperative to the life of the larvæ, and they perish. Thus an invasion of a new field from an old one may be prevented. But if the fallowing be delayed, even for a few weeks, the larvæ will then have for the most part passed into the pupal stage, during which no food is required, and plowing can have little or no effect upon them. This measure, together with the practice of allowing clover fields to stand only two years, would soon reduce the pest to subjugation in any community. No trouble seems to occur in pastures. Once brought under control, it would seem that a system of rotation that involves mowing for hay and seed the first year, pasturing and then breaking up the ground the following year, if generally followed in a community, would suffice to keep the pest in subjection. Extermination is not possible.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *December 28, 1905.*

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United States Department of Agriculture,
BUREAU OF ENTOMOLOGY,
L. O. HOWARD, Entomologist.

THE TOBACCO THIRPS AND REMEDIES TO PREVENT "WHITE VEINS"
IN WRAPPER TOBACCO.
(*Euthrips nicotianæ* Hinds.)¹

By W. A. HOOKER, *Special Field Agent.*

In the tobacco thrips, an insect until recently unknown to science, we have a pest that has become of great economic importance. It is closely related to the minute yellowish wheat thrips (*Euthrips vitici* Fitch) that is common everywhere in blossoms of all kinds. It may be distinguished, however, by its brown color. The common onion thrips (*Thrips tabaci*) of this country was originally described by Lindeman as attacking tobacco in Russia, but since it has never been found to do so in the United States, this new pest may be termed "the tobacco thrips."

This insect injures shade-grown cigar-wrapper tobacco in Florida, southern Georgia, and Texas, and thus appears to be widely distributed through the South. Its occurrence in Texas was discovered the past summer. The adult thrips in feeding on the upper surface of the leaves, as is their custom, remove the sap from the lateral veins and veinlets, which when damaged and ready for the juice become of a much lighter color than the other parts of the leaf. These light veins (fig. 1) are objectionable, since they appear in the manufactured cigars. As a result, tobacco thus affected is reduced in

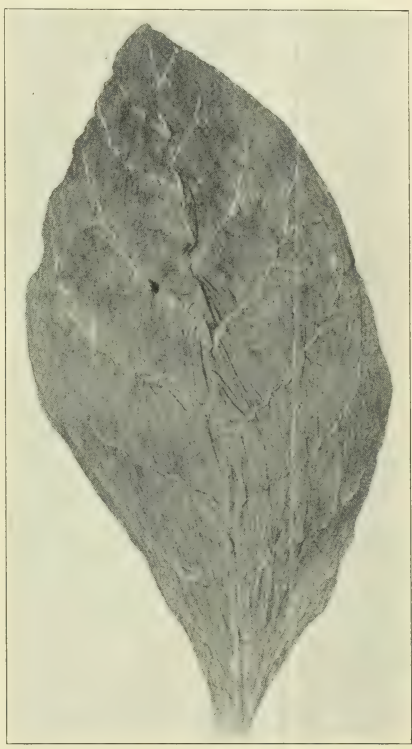


FIG. 1.—Leaf of tobacco, showing "white veins" caused by *Euthrips nicotianæ* (original).

¹ Described in the Proceedings of the Biological Society of Washington, Vol. VII, pp. 197-200, September, 1905.

value at least 50 per cent. The expense in grading is also largely increased. When we consider that the tobacco thus injured is the highest grade grown in this country, it will be seen that the loss thus occasioned is a large one.

The adult tobacco thrips (fig. 2) appear to pass the winter in the tobacco fields. They were found in the fields when first visited, the middle of April, feeding upon the young cocklebur, the principal weed. From the weeds they spread to the tobacco plants when the latter were transplanted. They first appear upon the lower leaves, from which they spread to the leaves above, the lower leaves thus being the worst affected.

The eggs are deposited in tissues of the stem and leaves. On hatching, the larvæ feed largely on the lower surface of the leaves, but as



FIG. 2.—*Euthrips nicotianæ*: Adult insect, much enlarged (original).

they reach the adult stage seem to prefer the upper surface, and this habit is taken advantage of in remedial treatment. The life cycle is passed in twelve or thirteen days. By this rapid reproduction from the comparatively few that pass the winter successfully, they soon reach vast numbers and become the source of extensive injury. After the tobacco is harvested the thrips live on the weeds in the field until cold weather drives them into hibernation.

REMEDIES.

Remedies may be considered under two heads, namely, cultural methods and insecticide applications.

CULTURAL METHODS.

The practice of locating the seed bed in the tobacco field is a bad one, as it furnishes a breeding place from which to spread into the field, not only for thrips, but for other pests, flea-beetles especially. When necessary so to locate the seed bed, frequent applications of kerosene emulsion, as herein described, and arsenicals, should be made.

At present it would seem advisable that clean culture be practiced between crops. It may be found, however, that kerosene emulsion will sufficiently control the pest, in which case catch crops may be grown.

a few days without rain can not safely be counted on. So poor were the results, in fact, that the writer felt inclined to doubt the effectiveness of these washes even in California. But subsequent trips to California and careful investigation of conditions there, demonstrated to his complete satisfaction that the effectiveness of these washes on the Pacific coast had not been overstated.

'CALIFORNIA WASH AGAIN TESTED.

The confirmation thus gained of the value of the California wash as an insecticide led the writer in the spring of 1900 to again institute some experiments with it against the San Jose scale and the Diaspis. These experiments are recorded in detail in Bulletin 30 (new series) of this Office, pp. 33-39. They include also parallel experiments with kerosene emulsified in the Bordeaux mixture and kerosene-lime emulsion, both suggested by Professor Galloway; and also a test with white-wash made at the suggestion of Doctor Howard. A special steam-plant was prepared, so that the lime, sulphur, and salt wash could be made after the most approved methods and thoroughly boiled. An account of these experiments, so far as they apply to the lime, sulphur, and salt wash, is transcribed below from the publication cited. The report of the chemist on this mixture is of especial value and seems to confirm the view previously expressed on the relative effect of a moist and of a dry climate on the behavior of the wash.

RECORDS OF EXPERIMENTS IN 1900.¹

Lime, sulphur, and salt wash.—A mixture of this substance was prepared, differing slightly from the formula given in Farmers' Bulletin No. 19 in that the amount of lime was somewhat reduced, namely, from 40 to 30 pounds. This reduction in the amount of lime was made simply because in the ordinary formula the lime is very greatly in excess and remains as a pure lime sediment in the wash and has to be kept in suspension by agitation. Even as thus reduced there is still a considerable excess of lime. The formula followed was:

Lime	-----pounds--	30
Sulphur	-----do-----	20
Salt	-----do-----	15
Water	-----gallons--	60

The mixture was steam boiled all together in barrels about four hours and applied March 23 and repeated March 24. The hot liquid was taken immediately from the barrels at almost a boiling temperature and sprayed at once on the trees. A series of experiments was also made with the preparation of this wash on a smaller scale, following practically the same formula. The products obtained were submitted to the Chemist of this Department for analysis, and the assistant chemist charged with the work was especially advised just what features were supposed to be desirable and what points the analysis should bring out. The result of this analysis, made by Mr. J. K. Haywood, of the Bureau of Chem-

¹ Bul. 30 (new series), Div. of Entomology, pp. 34-37.

istry, as reported by Dr. H. W. Wiley, Chief Chemist, is given in a footnote.¹ It is very interesting and valuable as showing the probable exact chemical nature of the wash in a dry climate and correspondingly also in a wet climate, in these respects practically substantiating the theory which the writer had announced several years ago. The practical application of this wash, as described above, was made to pear and plum trees, both infested with the San Jose scale, the plum trees being very thickly covered with the scale from top to bottom and the pear trees scaly from the butts upward three or four feet, scattering more or less over the whole tree. The plum trees had also more or less of *Diaspis pentagona*.

The question naturally arose, in view of the extreme heat at which the liquid was applied, whether any results gained might not be due to the high temperature of the liquid rather than from any insecticidal action. To test this matter some plum and peach trees covered with *Diaspis pentagona* were sprayed on March 27 with water at boiling temperature, or nearly so, the nozzle being held within 3 or 4 inches of the bark and the spraying being very thoroughly done. At a distance of 18 inches, as tested by spraying one's hand, the mist or spray was barely warm; at a distance of 12 inches, fairly hot; and very hot at from 4 to 6 inches. The bark of the trees sprayed was cold to the hand as soon as spraying stopped. This hot-water spray, brought to bear closely on the scale insects, it was thought would kill them, although it would of course be impracticable to make such close-range application in general practice. On the contrary, however, the scales remained in a vigorous, healthy condition, and apparently did not suffer in the least from the warm douche.

The results, therefore, gained by the lime, sulphur, and salt wash may be properly ascribed, it is believed, to a true insecticidal value of the substance rather than to the temperature of the application. The trees treated with this wash remained nearly snow-white, little, if any, of the mixture being taken off by the light snow and rain of the 25th and 26th instant. Discoloration of the *Diaspis* began to be noticed on the 27th instant. On April 13 the *Diaspis* scale insects killed ranged between 20 and 50 per cent on the young, vigorous limbs. All were dead on the old trunk, where the wood was in a very unhealthy condition owing to the completeness of the infestation, both by the *Diaspis* and the *Aspidiotus*. The San Jose scale, so far as investigation could determine, seemed

¹ The lime, salt, and sulphur wash, as finally prepared, contains the following substances in solution: A large amount of (CaS) calcium sulphid, some of the higher sulphids of Ca (as CaS₃ and CaS₅), small amounts of (CaSO₄) calcium sulphate, and traces of (CaSO₃) calcium sulphite, and a large amount of (CaS₂O₃) calcium thiosulphate; also some of the excess of Ca(OH)₂ lime is in solution. The residue is composed of lime.

On evaporating down a portion of the wash, with blast and at a gentle heat, no decided change takes place. Calcium sulphid still remains, as does calcium thiosulphate. A small amount of sulphur is deposited (doubtless from the polysulphids of calcium), and the amount of calcium sulphate is increased to a small degree.

If such a wash were applied to trees in a dry climate, the various compounds formed would remain for a long time and only gradually decompose. Eventually, however, the calcium sulphid would decompose, most likely forming calcium sulphate and some hydrogen sulphid (H₂S), and the calcium thiosulphate would decompose, first setting free sulphur and calcium sulphite, which last would oxidize to calcium sulphate. The lime would change to calcium carbonate (CaCO₃) and the polysulphids would break down, yielding sulphur and calcium sulphid, which would in turn change as above.

In a wet climate the calcium sulphid and the calcium thiosulphate would soon leach out, leaving behind small amounts of calcium sulphate and a large amount of lime, which would in turn form insoluble calcium carbonate. In this latter case the tree would still remain white and appear to still have the wash upon it, but, in fact, very little other than the calcium carbonate would be left.

to be killed completely; no insects were found on the young, vigorous shoots or older wood. The trees were still whitened with the wash, which had not been carried off to any very great extent by the heavy rains of April 11 and 12. The infested trees, especially those that had been pruned back, made a very vigorous growth, and the fruiting and growth of the others were entirely satisfactory.

In this experiment, which differed so remarkably in results from other experiments made in the East with this substance, it must be noticed that the weather conditions were exceptionally favorable. The application was made on March 23, and no washing rains followed until April 11 or 12, the light rain and snow of the 25th and 26th of March being not enough to vitiate the wash particularly, as very little of the snow rested on the trees, and much that did gain lodgment fell or was blown off subsequently. A very light shower occurred on April 4, but the first heavy downpour and long rain occurred on the night of April 11.

This experiment would seem to indicate that if one could count on a week or two of good weather following an application, the lime, sulphur, and salt wash might be as beneficial in the East as on the Pacific coast. Its cost is inconsiderable compared with the other treatments for the San Jose scale.

During the summer of 1900 the writer spent considerable time in California and saw a great many deciduous orchards that had been treated with the lime, sulphur, and salt wash. This treatment had been made in the winter or early in the spring, before the trees had begun to leaf out, and at the end of August the trees were still distinctly whitened by the application, there having been no rains in the interim to remove it from the bark. Under such circumstances it is plainly to be seen that this wash has the maximum chance of effectiveness, and that it is thoroughly effective under these conditions, is beyond question. Its effectiveness is undoubtedly, in the first instance, chiefly due to the direct insecticidal action of the mixture; and possibly, secondarily, in protecting the tree by the limy and sulphurous coating, which remains for months and is undoubtedly distasteful to the young scales coming from old individuals which may have escaped, and perhaps retains enough of its insecticidal value to destroy many of them.

RECOMMENDATIONS BASED ON THESE EXPERIMENTS.

On the strength of these experiments the lime, sulphur, and salt wash has been since recommended by us, as already stated, as a remedy for San Jose scale in the East, with the understanding that unfavorable weather conditions, that is, heavy rains, immediately following treatment, may very probably decrease the benefits to be derived from it. That under favorable conditions its use may be thoroughly satisfactory, as much so as kerosene or crude petroleum, was fully demonstrated.

WORK DONE BY OTHER EXPERIMENTERS.

In the winter of 1901-02 Prof. S. A. Forbes instituted certain experiments with the California and Oregon washes, and his results of a highly satisfactory nature are given in Bulletins 71, 72, and 80 of the Illinois Agricultural Experiment Station. In brief, these seem to indicate that either the California wash or the Oregon wash, the preference in the later publications being given to the former, can be used under Eastern conditions with the probability of satisfactory results irrespective of weather conditions; in other words, Professor Forbes' experi-

ments were directed particularly to determine whether washing with rain or artificial washings of sprayed trees would affect the efficiency of the wash, and, rather surprisingly, such washings seemed to have had no prejudicial effect.

From the experience up to the present time it does not seem reasonable to assert from Professor Forbes' results alone that the California wash is not affected by hard washing rains, especially in view of the tests made by the Department Chemist, and the less favorable or contradictory results obtained by other experimenters, nevertheless the evidence is sufficient, on the whole, to warrant the placing of this wash among the best of the remedies in the East against the San Jose scale.

The work in Illinois has been supplemented by independent experiments in New Jersey, New York, Maryland, Georgia, and other States, and while all tests have not been successful, they seem to indicate that the lime, sulphur, and salt wash will, in the majority of instances, give decidedly good results, often destroying the scale nearly as effectively as an oil or a soap application.

HOW THE WASH AFFECTS THE SCALE INSECT.

The action of this wash on the scale is very slow and, judging from Professor Forbes' experience, it is possible that in the case of our preliminary work in Maryland in 1894, if the trees had been left for the summer without other treatment, the lime wash might have continued its effect and exterminated the scale in a much greater percentage than was the case in April. This wash coats the tree thoroughly, has a decided caustic insecticidal effect, and dissolves, to some extent, and loosens the scale covering, so that a large number of scales perish during the winter and early spring, and this action continues until the emerging of the first brood of young. As indicated above in the quotation from Bulletin 30, the weakened wash remaining on the trees through early summer may still be strong enough to kill some of the delicate larvæ and act as a deterrent to the settling of others until they perish. In fact, the chief benefit seems often to come at this season.

CAUTION IN ESTIMATING RESULTS.

It should be remembered that the sudden increase in the percentage of dead San Jose scales on trees in April may not necessarily be due to the wash, but rather to the fact that the male insects transform to the winged stage in April long before the females reach full growth, and hence there is an appearance of a sudden increase of dead scales, the abandoned scale covering of the male insect still adhering to the bark. This may often amount to 95 per cent of the scales. In the spring of 1902 the male scales in the Department orchard represented fully 95 to 98 per cent of the living insects on the trees in early April. The hatching of these, of course, gave an immediate appearance of an almost

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BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS AFFECTING THE PRODUCTION OF RED CLOVER SEED.

By F. M. WEBSTER,

In Charge of Cereal and Forage-plant Insect Investigations.

Our knowledge of the two insects here given more special consideration—the clover-flower midge and the clover-seed chalcis—is still somewhat obscure, and particularly so in the case of the latter. In the following pages the effort has been made, not so much to present a finished treatise as to place within reach of the practical farmer, in a condensed form, all available information relative to some of the insects that, in one way or another, affect red clover seed. At the present time cultivation of this valuable crop for seed is frequently attended by losses, more or less serious, or even by total failures, the causes of which are not at all well understood by the agriculturist. Bumblebees, or some similar agency, are necessary to the pollination of the clover blossom. It is possible, however, that many failures of the seed crop heretofore attributed to a scarcity of bumblebees may in reality be due to the destructive work of the insects herein described.

These two insects have been selected both because of their economic importance and also on account of their interrelations, not only with each other—as the presence of one in a floret precludes the existence of the other—but also with other clover insects.

RELATIONS OF THE TWO INSECTS.

What has until very recently been termed the clover-seed midge is in all probability not a seed-infesting insect at all, but one which attacks the ovaries, probably destroying them before they are fertilized, and certainly before seeds can develop. The clover-seed chalcis lives in the seeds only; therefore, when the first occurs it is impossible for the second to exist.

INTERRELATIONS WITH OTHER INSECTS.

No influence of the bumblebee can produce seed where its visits to the florets have been anticipated by the maggots of this midge. But the complication does not end here by any means. Another insect, the clover-leaf weevil¹ (fig. 1), a beetle introduced into this country by acci-

¹ *Phytonomus punctatus* Fab.

dent many years ago, probably from Europe, and now known to occur from New England to North Carolina and Wisconsin, attacks the clover plants in spring after they have made some growth and, in cases of excessive abundance, leaves the ground as bare of clover in May as it was in December. It does not, however, injure the roots, and soon the plants spring up and the fields become as green with clover as before, the final result being that only the blooming is retarded. That this delay is fatal to the midge has been shown, again and again, by the heavy crops of seed that have been secured from fields overrun with the weevils in May. A further complication is found in the fact that the

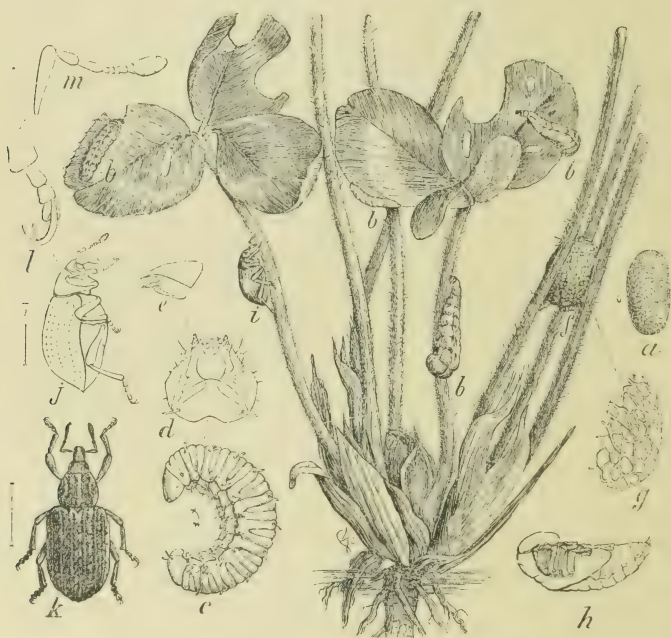


FIG. 1.—The clover-leaf weevil (*Phytonomus punctatus*): a, egg; b, b, b, b, larvæ feeding; c, recently hatched larva; d, head of same from beneath; e, jaw of same; f, cocoon; g, meshes of cocoon; h, pupa; i, beetle; j, same, in outline; k, same, dorsal view; l, tarsus of beetle; m, antenna of same (b, f, i, natural size; others more or less enlarged). (From Riley.)

clover-leaf weevil does not become excessively abundant and eat off the clover every spring, because a fungous parasite attacks the larvæ, causes them to die off by myriads, and thus keeps the insect greatly reduced in numbers.

To summarize, the clover-seed chalcis attacks an important seed crop; but the flower midge destroys the ovaries before these have been fertilized by the bees and seed developed, thus checking the chalcis; the leaf weevil, however, eats off the clover plants in spring, so that blooming is delayed until after the midge is obliged to deposit its eggs, thus restricting its breeding; while the insect-destroying fungus keeps

the leaf weevil from subjugating or exterminating the midge, by causing the death of the young weevils.

All of this conflict is going on to a greater or less degree each year in the clover fields of the farmer, and for the most part without his knowledge; nevertheless he is a gainer or a loser in proportion as each insect increases or decreases in abundance. A knowledge of these conditions will better enable him to devise practical means to protect his crop and avoid loss.

THE CLOVER-FLOWER MIDGE.

(*Dasyneura* [*Cecidomyia*] *leguminicola* Lint.)

This minute insect, shown in figures 2 and 3, is a near relative of the wheat midge,¹ which it resembles in form and color. The larva, or maggot, also bears a similar resemblance in shape and color; hence farmers, in searching for the clover-flower midge, should look for something very like what has been long, though erroneously, known as the "red weevil" in wheat, and will frequently find it in sufficient abundance among the hulled clover seed to attract their attention. In drawing in clover hay these maggots are frequently shaken from the cured blossoms in such numbers that the bottoms of the wagon racks become literally covered with their reddish bodies.



FIG. 2.—The clover-flower midge (*Dasyneura leguminicola*): a, enlarged side view of female, with scales denuded, to show more clearly the structure; b, head, more highly magnified, to show structure of the eye, palpi, and basal joints of antennæ; c, tip of ovipositor, highly magnified and showing at end of next to last joint the manner in which it is clothed with minute hair; d, highly magnified antennal joints, their minute hairy clothing shown on the lower one. (From Riley.)

DESCRIPTION.

The adult insect (fig. 2, female; fig. 3, male) is a minute two-winged fly. The head and thorax are black, the latter clothed with rather long hairs. The antennæ are long, those of the female (fig. 2) sixteen or seventeen jointed and those of the male (fig. 3) fifteen-jointed. The wings are nearly transparent and clothed with numerous short, curved, blackish hairs, giving them a dusky appearance, each wing having three longitudinal veins, the third vein being either forked or more or less obsolete toward the tip. The wings are also fringed with hairs that are longer and paler than those on the surface. The abdomen of the female

¹*Contarinia* (*Diplosis*) *tritici* Kirby.

(fig. 2) is reddish, with black hairs on the back of each segment. The abdomen of the male (fig. 3) terminates with a pair of clasping organs, while that of the female is provided with a long, pointed, extensile ovipositor, about twice as long as the remainder of the body.

The egg is only about one one-hundredth of an inch long, oval, about three times as long as broad, pale yellow when first deposited, but becoming tinted with orange as it nears hatching.

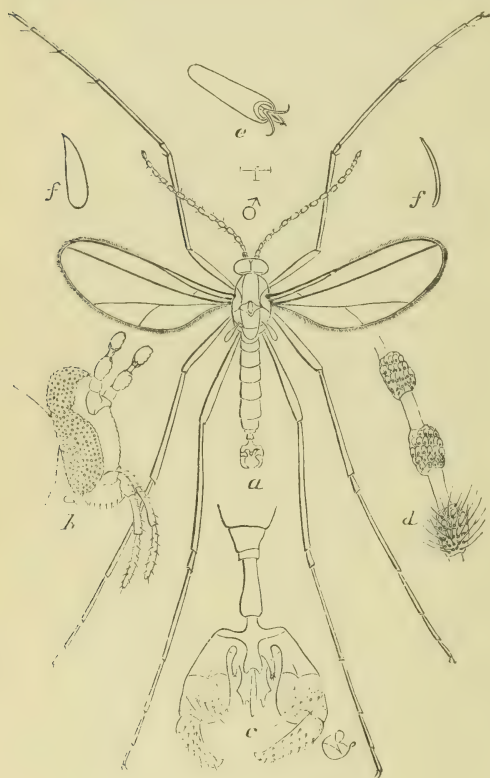


FIG. 3.—The clover-flower midge (*Dasyniura leguminicola*): a, enlarged dorsal view of male with scales denuded; b, head; c, genitalia; d, antennal joints, more highly magnified, to show structure; e, tarsal claw; f, f', forms of scales. (From Riley.)

The larva (fig. 4) when full grown is about one-twentieth of an inch long, footless, ranging in color from nearly white to orange-red, according to age.

The pupa is pale orange in color, with brown eyes. On the front of the head are two short, conical tubercles, and behind them two long bristles. The sheaths inclosing the antennæ are curved outward like the handles of an urn.

LIFE HISTORY.

The pupa is inclosed in a compressed, tough, oval silken cocoon, and when the fly is ready to emerge the pupa pushes itself out of this cocoon to the surface of the ground.

It is within the cocoon that the winter is passed, and the time in spring when it comes forth as an adult varies with the latitude and

season, probably closely corresponding to the heading of red clover.

After pairing, the female proceeds to deposit her eggs in the clover head, pushing them beneath the bracts or enveloping leaves, or down between, but not fastening them in any way to the seed capsule, and in no case, so far as observed, within the florets. Although deposited singly, Professor Comstock reports as many as 50 eggs in a single head.

In hatching, the larva must make its own way into the open end of the floret, which offers only sufficient quarters for one individual. In this floret it feeds, and from it, when full grown, it makes its exit and

drops to the ground, into which it usually descends a short distance. Here it forms a tough silken cocoon, to which particles of earth adhere, giving it the superficial appearance of a little lump of soil. From the cocoons the adults emerge in time to oviposit in the second or seed crop of bloom, and the same mode of procedure is gone through with again, except that this time the insect hibernates in the cocoon and the midges do not appear until the following spring.

It will thus be observed that there are two annual generations, the flies appearing simultaneously with the first and second blooming periods of the clover. While they thus appear earlier in the South than in the North, it is doubtful if there are more than two broods throughout the area over which red clover (*Trifolium pratense*) is grown, though the broods may be more prolonged or widely separated to the southward.

EFFECT UPON THE PLANT.

There is no material effect on the stem or foliage, but the heads quickly indicate the presence of the maggots by failure of the florets to develop, becoming reduced in size, often distorted, and lacking the familiar pinkish color more or less. In fact, the abundance of the pest may be approximately estimated by the appearance of a clover field during the blooming season.

DISTRIBUTION.

Although the pest did not attract more than local attention until 1878 and was not described until a year later, there is considerable evidence indicating that it was injurious in New England at least thirty years prior to these dates. Dr. S. A. Forbes, also, found good evidence of its occurrence in Illinois at about the time of its discovery in New York by Lintner. One of the writer's assistants, Mr. G. I. Reeves, found it occurring in Nebraska in destructive abundance in 1904, though Prof. Lawrence Bruner did not know of its occurrence in that State in 1898. The late Miss Ormerod reported its occurrence in England in 1890 and stated that it had probably been present in the clover fields there for several years. In America it probably occurs wherever mammoth, crimson, white, or the common red clovers are grown.

NATURAL ENEMIES.

One of the first parasites to be reared was bred in 1879, at Washington, D. C., from material sent from New York. It is a minute black four-winged fly¹ which the writer reared also from the larvæ of the wheat

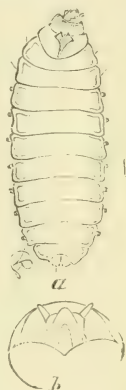


FIG. 4.—Clover-flowermidge: a, larva enlarged, ventral view; b, head retracted, highly magnified. (Riley.)

¹ *Anopediæ error* Fitch, family Platygasteridæ.

midge in Indiana in 1884. It does not finish its transformation until after the maggots have left the clover heads and constructed their cocoons in the ground, and therefore emerges from the cocoons and not from the clover heads.

Two species of *Tetrastichus*, both small, mostly black or bronze-colored four-winged chalcidid flies, were reared in immense numbers in the spring of 1905 from clover heads collected about Lincoln, Nebr., during the preceding December. In this case the adult parasites were reared from both larvæ and pupæ taken in midwinter from infested clover heads, and their abundance is an indication of their efficiency in destroying the midge.

PREVENTIVE MEASURES.

Fortunately there are two equally efficient and practical measures that can be applied, each to different field conditions. If the meadow to be protected consists of clover alone, and not a mixture of clover and timothy, the hay should be cut quite early, not later than the second week in June, in ordinary seasons. In the latitude of northern Ohio, Indiana, and Illinois this will be just before timothy is headed, but, of course, the date will be earlier to the south and later to the north. As clover alone will stand earlier harvesting without injury to the hay crop, this method is entirely feasible; and it seems either to destroy the larvæ of the midge or to so hasten the second blooming that, by the time the second or fall brood of midges appears the blossoms have become too far advanced for the maggots to work in them.

The second measure can be applied where, as is more often the case in the Middle West, timothy and clover are grown together. While dairymen and cattlemen prefer clear clover hay, horsemen prefer timothy with little or no clover. Besides, in some sections of the country, the clover seems to gradually displace the timothy, while in others the reverse is the case, the relative proportions of each being, therefore, more or less unstable. In such cases it is understood by the farmers that a mixed meadow with much timothy needs to stand longer before mowing than in case of clover alone, a condition that can be effectually met by pasturing meadows lightly or running a mower over them and clipping back the growth—probably not later than the middle of May to the south, while Doctor Fletcher, in Canada, states that in his northern latitude it must be done not later than June 20. This treatment of a meadow of clover and timothy combined only checks the growth temporarily, precisely as does the work of the clover-leaf weevil, so that both first and second blooming of the clover portion come too late for the destructive work of the midge, and the hay crop, as a whole, sustains no loss. This retardation may slightly delay the haying in meadows so treated, but this hay can be cut while the timothy is in bloom or afterwards, as suits the desire of the owner.

In putting either one of these methods into practice, the farmer will have to use his own judgment as to exact dates, as seasonal influences affect both the time of blooming of the clover and the appearance of the midges. He must also see to it that roadsides and margins of fields are prevented from becoming nurseries for the midge, from which they may easily migrate to his fields.

THE CLOVER-SEED CHALCIS.

(*Bruchophagus funebris* How.)

The differences between this insect and the preceding have already been pointed out. Its habits are decidedly anomalous. It belongs to a family of parasites whose office it is to prey upon and destroy other insects; and it was largely this conception of its mode of living that caused it to be first described as a parasite of the clover-flower midge, and thus to be looked upon as a friend of the farmer instead of as an enemy. This opinion was universal up to 1896, when Dr. A. D. Hopkins, then of West Virginia, called attention to the misconception, but even at that late date his conclusions were not generally accepted as correct. Since that time, however, the insect has again and again been proven, by rearing, to be a vegetable feeder, by investigators within this Bureau and by others, until there can no longer be a shade of doubt regarding its clover-seed-destroying habits. Both this and the midge may inhabit the same heads of clover, but not the same florets.



FIG. 5.—The clover-seed chalcis (*Bruchophagus funebris*): Adult female, much enlarged; antenna of the male at left, more enlarged. (Original.)

DESCRIPTION.

The adult insect is shown enlarged in figure 5. It is of small size, compact form, and general black color, with dark-brown eyes, and with the lower portion of the fore legs and all the feet light brown.

The egg (fig. 6) is whitish, smooth, polished, slightly elongate, with a long, slender pedicel. It is deposited directly in the otherwise perfect seed.

The larva (fig. 7) is of much the same color as the egg and when full grown practically fills the empty shell of the seed, the contents of which it has consumed.

The pupa (fig. 8) is at first whitish, but later changes to brown. It develops to the adult within the seed and in this last stage eats its way out of the now empty seed shell.

LIFE HISTORY.

It is probable that the insect passes the winter in the seed within outstanding clover heads in the field, and it may do so either as larva or pupa.

Doctor Hopkins and Mr. E. S. G. Titus, both of whom have witnessed



FIG. 6.—The clover-seed chalcis: Egg, highly magnified. (Original.)

oviposition, state that the female crawls down among the florets and pushes her egg into the seed, which at this time is in a semifluid state. As this is practically the condition of the seed until it becomes full sized and begins to harden, it is not yet clear just how the larva feeds during this time, but in all cases the larva develops within the seed, and from it the adult emerges. Mr. Titus found that a larva sometimes abandons one seed and, eating its way through the inclosing floret into an adjoining one, enters another seed. In one instance observed, a single larva appeared to have in this way reached and partly devoured three seeds. This would account for the shrunken or partly developed seeds, frequently charged up to the midge. Developing within the seed, it seems probable that the adults issue

therefrom at the usual time when the seed of the second bloom has begun to form, and that the same mode of procedure is followed as before, except that the adults from these seeds do not appear until late in the following spring or early in the summer. While future investigations may necessitate modifications of this supposed life cycle, it will probably be found, in the main, correct, and, if so, it would seem that the less number of seeds produced by the first bloom might act as a restraint upon the excessive abundance of the insect in the second. However, as cases are known in which from 50 to 85 per



FIG. 7.—The clover-seed chalcis: Larva, much enlarged; head at right, more enlarged. (Original.)

cent of the seeds of a single head were infested, it will readily be seen how serious a pest it can become in the clover field with no other restraint put upon its increase. Its presence is most assuredly never beneficial.



FIG. 8.—The clover-seed chalcis: Pupa, much enlarged. (Original.)

FOOD HABITS AND EFFECTS UPON THE PLANT.

The food plants are known to include the seed of red and crimson clovers and alfalfa.

There appears to be no visible effect upon any part of the plant attacked except the seed. Even badly infested heads can not be distinguished from those uninfested. At present it seems that a serious loss to the clover-seed crop may be caused by this insect, without the farmers being in any way able to account therefor, as the shriveled and imperfect seeds are mostly

blown out with the chaff in hulling, as are also more or less of those infested.

DISTRIBUTION.

The insect is known to occur from New England to Oregon, Washington, and California on the west, and south to Mississippi; and, in fact, it may be confidently looked for wherever its food plants are grown.

NATURAL ENEMIES.

While parasites have been frequently reared from infested clover heads, it is as yet impossible to say whether they had preyed upon this or some other insect occurring with it.

PREVENTIVE MEASURES.

While it would seem that the same measures recommended for the flower midge might apply to this insect, more careful study and experimentation than have yet been given the subject will be necessary before we can secure definite assurance that this is so.

If all outstanding clover heads were destroyed and the chaff and stems burned after hulling, this would in all probability greatly reduce its numbers the following year, even if it did not exterminate it.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *April 12, 1906.*

CIRCULAR NO. 70.

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE HESSIAN FLY.

(*Mayetiola* [*Cecidomyia*] *destructor* Say.)

By F. M. WEBSTER,

In Charge of Cereal and Forage-plant Insect Investigations.

Probably no other insect causes more damage to the wheat crop of the United States than the Hessian fly, though the chinch bug is doubtless a close second. During years when it is excessively abundant, hundreds of thousands of acres of wheat may be either totally destroyed or so badly injured as to reduce the yield 50 to 75 per cent, and the monetary losses expressed in dollars would run far up into the millions. This insect is an old depredator, in the sense that it has long been known to ravage our wheat fields, yet farmers are, in many cases, still at a loss regarding the best methods of warding off its devastation.



FIG. 1.—The Hessian fly (*Mayetiola destructor*): Adult female, much enlarged (original).

EARLY HISTORY IN AMERICA.

The common name, "Hessian fly," was long ago bestowed upon this insect by Americans, because of its having committed some depredations on Long Island, New York, in 1779, in the vicinity of Lord Howe's old encampment of three years before. The Hessian merce-

naries who constituted a part of this army were much despised, both at home and in America, and, on the supposition that these soldiers



FIG. 2.—The Hessian fly: Adult male, much enlarged (from Marlatt).

had brought the pest with them from their native country in the straw used for their bedding while en route, it was given the obnoxious name of "Hessian fly." Whether or not this theory of its introduction was well founded can never be either substantiated or disproven, and all that can now be said is, that the pest was imported, probably from some trans-Atlantic country and some time during the latter half of the eighteenth century. As a matter of interest, it

may be stated that, in some quarters, the more ignorant Tory element of those days claimed that General Washington was responsible for this pest. It was not technically described until 1817.

DESCRIPTION OF THE INSECT.

The fly itself (fig. 1, female; fig. 2, male) is very small, being only about one-tenth of an inch long, the body of an obscure dark color, and the form much like that of a very small mosquito. The abdomen of the female (fig. 1) is red, or yellowish when first hatched from the "flaxseed," the color varying with age, the posterior segments terminating in a compressed cylindrical, very minutely hairy ovipositor, capable of great extension. The male (fig. 2) is smaller, more slender, and in color generally darker than the female, the abdomen terminating in a somewhat intricate organ composed of a set each of outer and inner claspers.

The egg (fig. 3) is very minute, being only about one-fiftieth of an inch in length, cylindrical, roundly pointed at the ends, glossy translucent, and slightly reddish, this color deepening with development.

The larva or maggot (fig. 4), when newly hatched, is a little smaller than the egg, with a slightly reddish tinge; later, as it increases in

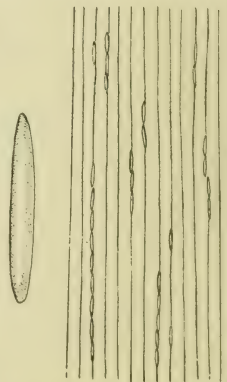


FIG. 3.—Egg of Hessian fly, greatly enlarged; section of leaf of wheat, at right, showing eggs as usually deposited, less enlarged (original).

size, it is at first white and afterwards greenish white, clouded internally by flaky white.

The flaxseed (fig. 6).—This is the name given to the insect after the larva has reached its full growth and the skin has hardened and turned brown, forming a covering known as a puparium. There is at this time a minute, brown, forked process on the underside of the anterior end of the larva, known as the "breastbone" (fig. 5), the use of which is not fully understood. It is not present, however, until the larva enters the flaxseed state. Within this "flaxseed" it transforms first to a pupa (fig. 7), and from this to an adult fly. The term "flaxseed" is applied partly because of its brown color and partly because it is more or less flattened, thus giving it somewhat the appearance of a flaxseed.



FIG. 5.—The Hessian fly: Larva taken from "flaxseed," much enlarged, with "breastbone" still more enlarged at right (original).



WHERE TO FIND THE DIFFERENT STAGES.

From the foregoing descriptions it will be observed that, during the life of this insect, it is found in four very different forms, so entirely unlike in appearance as to confuse the average farmer.

The eggs (fig. 3), which may be easily seen by one with fairly good eyesight, are generally placed in the grooves of the upper surface of the leaves, though they are occasionally found on the underside of the leaf. When the young wheat plant is just pushing through the ground, the egg is sometimes placed on the outside, because no leaves are available. The young larva is slightly smaller than the egg, and as soon as it is hatched it makes its way down the leaf and behind the sheath. In case of young wheat it descends to just above the root, but after the plants have begun to joint it can go no farther than the base of the sheath belonging to that particular leaf, which is always at the joint. Where excessively abundant, the larvæ will frequently be found on the lower stem ranged one behind the other, the anterior end of one pushed slightly under the posterior end of the one in advance. Very often this position is maintained throughout the entire development of the larva (figs. 4 and 5), and the flaxseeds (figs. 6 and 10) still retain the same relative position. The fall brood of larvæ and the overwintering flaxseeds are to be found just above the roots (fig. 10),



FIG. 4.—The Hessian fly: Larva before "flaxseed" is formed, much enlarged (original).



FIG. 7.—The Hessian fly: Pupa taken from "flaxseed," greatly enlarged (after Marlatt).



FIG. 6.—The Hessian fly: Puparium or "flaxseed," much enlarged (original).

except in cases where the young plant has become disintegrated and separated at the point of attack in the fall or the plants have been heaved out by the action of freezing and thawing, in which case they may be scattered about on the surface of the ground.

The young make their way down the plant head foremost, and so remain until before pupating, when they reverse their position in the flaxseed and are then situated head upward, and thus pass into the pupal stage. Before the fly issues, however, if the flaxseed is not situated conveniently for its escape, the pupa will push itself, if possible, to such a point, and frequently empty pupa skins may be observed protruding from under the sheaths of the leaves.

The fly itself is not easily observed until one becomes familiar with its appearance, and this will account for the great variety of insects that are continually mistaken by farmers for the Hessian fly. Much of this difficulty may be obviated if farmers will look for an insect like that shown in figure 1, but very minute and somewhat resembling a very small mosquito. During warm days, in the egg-laying season, the flies may be observed flying about in the young wheat, alighting upon the leaves. In cooler days, or in early morning while a heavy dew is on, they will be down among the leaves, or even on the ground.

LIFE HISTORY.

At present all indications point to the probability of the Hessian fly being two-brooded, at least during favorable seasons, over its entire area of distribution in the United States.

In the South the two broods are the most widely separated, while in the North, in the regions of spring-wheat growing, they seem to follow each other in quick succession.

LIFE HISTORY IN REGIONS OF FALL-WHEAT GROWING.

Throughout the fall-wheat-growing sections the fly passes the winter in the young wheat, mostly in the flaxseed stage, but also to some extent as from two-thirds to full-grown larva. It is difficult to estimate the number of these larvæ that will winter over and remain alive until spring, owing to the fact that it is impossible to determine whether they are alive or dead until they begin to decay. But where we have attempted to rear them, even though apparently alive, comparatively few adults have been obtained, though of course this mortality would probably vary somewhat with the severity of the weather during winter.

In spring (from March, in Georgia and South Carolina, to May, in Michigan) the flies escape from the flaxseeds and deposit their eggs on the wheat, and the young from these develop to flaxseeds before harvest, passing the summer in the stubble. The flies from overwintering larvæ come on later; and it is quite probable, also, that some of the very earliest deposited eggs may give rise to adults at about this

time; thus, owing to this overlapping, during some seasons and in some localities, there appears just before harvest what has by some been considered a supplementary second brood.

In autumn the time of appearance of adults as between North and South is reversed. In northern Michigan the adults of the fall brood are abroad, under normal meteorological conditions, during the last days of August and first days of September. In Georgia and South Carolina, under the same conditions, it may be the last of November or the first of December before they have all left the stubble. Thus has the species adapted itself to the prolonged southern summer, during which there is little or no food for the larvæ. While there are stragglers, the major part of the brood will appear and disappear within the space of a few days, probably within a week, and the flies, by preference, will deposit their eggs on the younger plants, those of one or two leaves seeming to suit them best. At this time the young larvæ make their way downward nearly or quite to the roots (fig. 10). The normal outcome of this brood is that the individuals reach their development as larvæ, pass into the flaxseed stage, and pass the winter as such on the young wheat plants. But here again the earliest deposited eggs may produce adults before the winter sets in, and the delayed individuals occurring at this time may unite and another supplementary brood, as it has been termed, may be produced. The economic significance of this so-called brood depends much on the weather, as, if winter sets in before the larvæ have sufficiently matured to withstand its rigors, these must necessarily perish, while, if the mild autumn weather is greatly prolonged, more or less of them may winter over uninjured.

LIFE HISTORY IN SPRING-WHEAT REGIONS OF THE NORTHWEST.

The statements here made are based largely on the careful investigations carried out by Mr. George I. Reeves, a special field agent of this Bureau, during the season of 1905. This single season may have been an exceptional one, in that the spring was backward, the summer wet, and the mild autumn weather continued later than usual. The results must not, therefore, be taken as wholly conclusive.

In North Dakota the insect winters in the flaxseed stage in both stubble and volunteer wheat, chiefly the former. Egg laying begins late in May, and during seasons with plenty of rain the second brood follows the first in quick succession, being reenforced by the continued emergence of flies from stubble of the previous year. Here the summer conditions are different from those in the East and South, and the breeding season extends from about May 20 to October 1, or throughout the entire summer. In other respects the habits of the insect do not seem to differ from what they are in the fall-wheat-growing section of the country.

DISTRIBUTION.

Outside of America the Hessian fly occurs in North Africa, western Asia, Europe, British Islands, and New Zealand. In the Dominion of Canada Doctor Fletcher has found it from Prince Edward Island to Indian Head, Saskatchewan. On the Pacific coast it probably occurs from southern California to British Columbia; but as no exact investigations have been made there, this statement is to be considered as only approximately correct.

Our previous notions of the distribution of this insect over the country east of the Rocky Mountains will have to be revised. The accompanying map (fig. 8) will show the extent to which this revision becomes necessary. The original of this map appears in Bulletin 16.

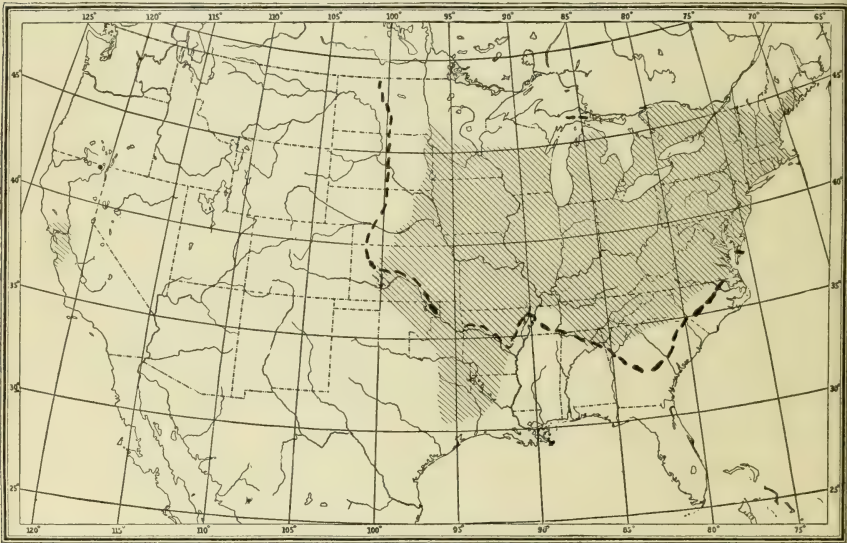


FIG. 8.—Map showing distribution of the Hessian fly in America (altered from Osborn).

new series, of this Bureau (issued in 1899). The heavy broken line indicates the present western and southern limits of Hessian fly distribution based on our latest observations and data furnished by Professor Bruner, of Nebraska, and Mr. R. I. Smith, entomologist of the Georgia State crop pest commission. This is believed to be approximately correct. It also seems to show that the insect must have been first introduced into the Pacific coast region in or with articles of inland commerce, and (unless it be found to infest native grasses) that it did not reach there by natural diffusion, a point that has not before been definitely stated so as to be clearly understood.

Experimental sowings of wheat near Sault Ste. Marie, Mich., during the last two years do not reveal its presence there, and no attempt

has been made to study its occurrence in the spring-wheat-growing sections of Maine. While its absence in some parts of the country between the Platte River, in Nebraska, and the Canadian boundary line might be attributed to a lack of its food plant, this will not hold in southwestern Kansas and Oklahoma, as in those localities it seems to suddenly terminate in the midst of a wheat-growing section, and where this grain has been cultivated for at least twenty years. Strange as this may at first appear, Doctor Merriam, of the Biological Survey, informs the writer that he finds several parallel cases in the distribution of some of the smaller mammals.

FOOD PLANTS.

While the female fly will often deposit her eggs on grass, or even weeds, the larvæ, so far as known, survive only on wheat, barley, and rye, proportionately in the order mentioned. From time to time "flaxseeds" closely resembling those of this insect have been observed on the stems of several native grasses, but adults reared from them have not been considered as belonging to this species, owing to supposed structural differences, and no experiments have been made to ascertain whether or not it is possible for larvæ of the Hessian fly to survive on these grasses. Doctor Forbes some years ago failed to induce the insect to breed in either redtop, bluegrass, foxtail, or orchard grass—species on which "flaxseeds" had, however, not been found.

Flaxseeds resembling those of Hessian fly have been found on *Elymus*, *Agrostis*, *Bromus*, and *Agropyron*, in California, by Mr. Koebele, and on the latter also in Indiana, by Mr. W. J. Phillips, a field agent of this Bureau. Besides, Doctor Lindeman found similar flaxseeds on timothy and *Agropyron repens* in Russia.

EFFECT OF LARVÆ ON THE PLANT.

The effect of the larvæ on a young wheat plant is very marked and becomes observable soon after the young reach the stem under the sheath. Once he has observed it, any farmer can readily detect an infested plant, or a single infested tiller may be as readily detected in a cluster without taking the trouble to remove the plant from the ground.

For the purpose of comparison, illustrations are given of an uninfested young plant (fig. 9) and an infested young plant (fig. 10). An uninfested plant is of a more slender growth, the green color is lighter, with a slight tinge of yellow, the stems are more or less visible, and the central unfolding leaf is present. The whole plant is inclined to droop and the tillers spread out and cover the ground. An infested plant is without stem and the leaves are broader, usually shorter and of a deep bluish-green color, somewhat resembling those of oats. The

plant stands more erect, and, in fact, is but a mass of short overgrown leaves that usually kill with the first frost. Figure 10 shows a young tiller starting out from below the part attacked by the fly. If this tiller were to be attacked after it appeared above ground, there would follow the same appearance as in case of the original plant; that is to

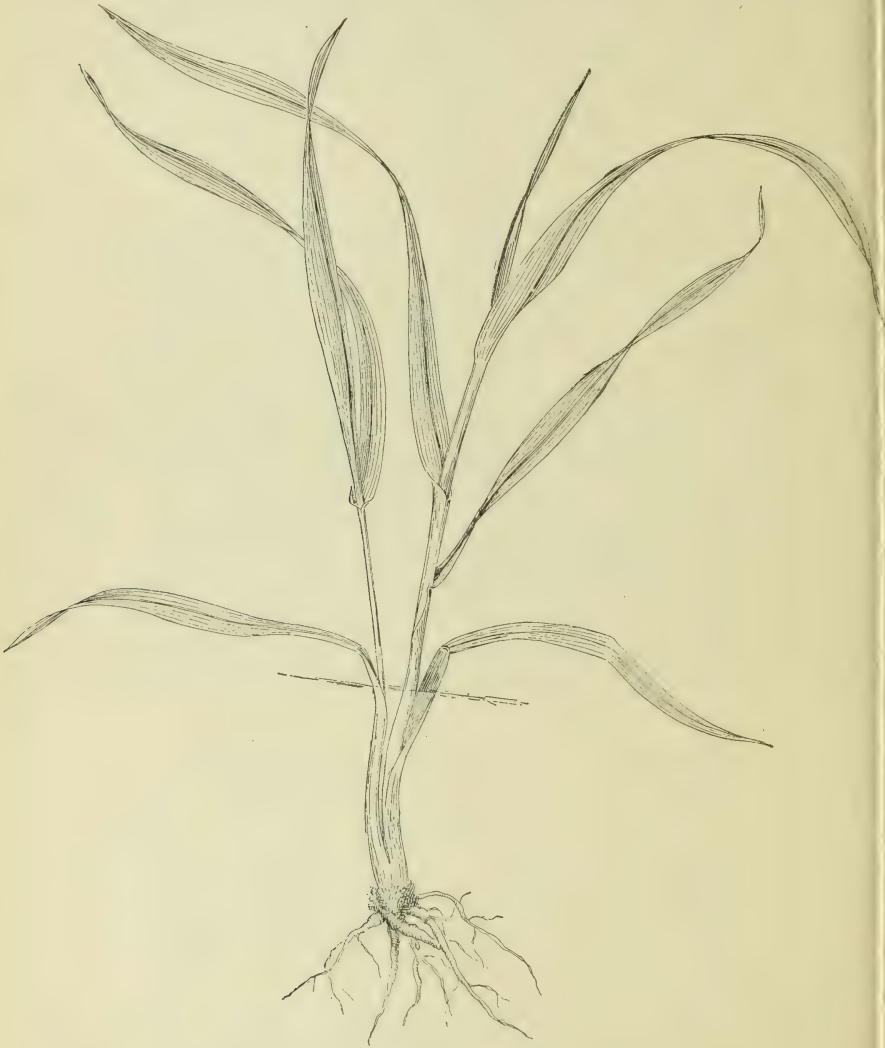


FIG. 9.—Healthy young wheat plant (original).

say, the leaves would become broader and of a darker color. The foregoing statement will apply to a severe attack on fall wheat in spring and on young spring wheat. The only exception in the appearance of infested young plants is in the case of the hard wheats, whose foliage is broader and of a darker color, but the erect position will

still enable the observer to detect the infestation. Of course later on the infested plants change to yellow and then brown, but the darker color and rank growth of leaf always precede this.

In summer, in both spring and fall wheat, the effect of the fly is to

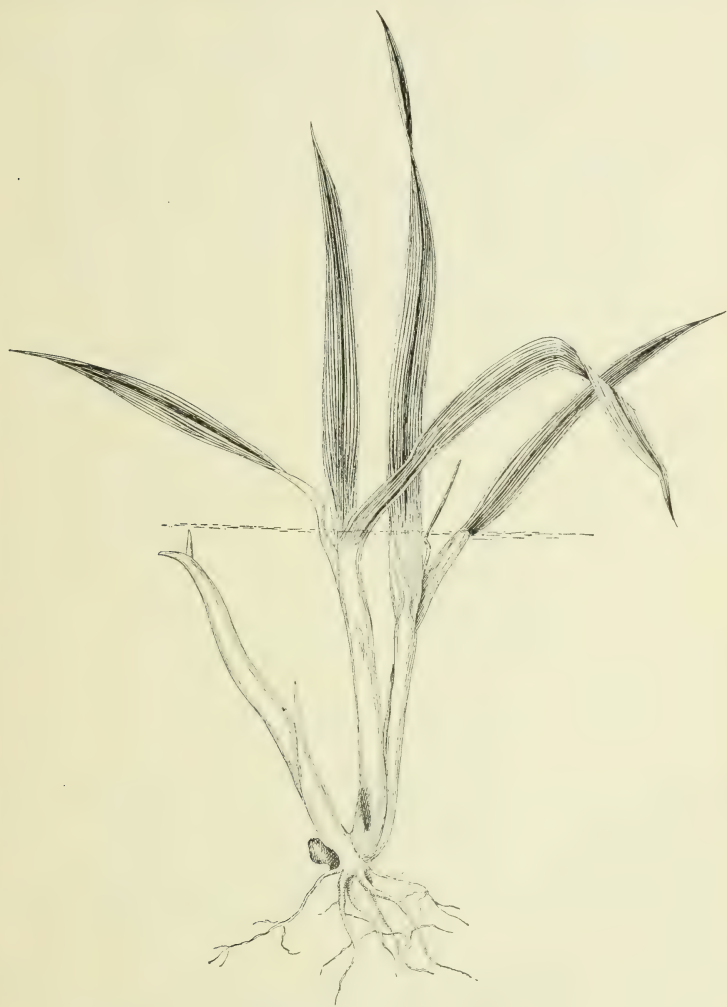


FIG. 10.—Young wheat plant infested by the Hessian fly (original).

cause the straw to break over before harvest. It is then said to be “straw fallen.”

IMMUNE OR DISTASTEFUL VARIETIES OF WHEATS.

There is no such thing as “fly-proof wheat.” Most wheats will suffer when the plants are young, regardless of variety. In experimental sowings a variety that seems to escape attack one year may suffer

the next; and, while the insect may prefer certain varieties over others, this all comes to naught in years of serious ravages or where the supposed distasteful variety is in a condition more satisfactory to the insect at the time of oviposition. It is doubtful, however, if this can be said of the attack of the second brood on the more matured plants, as it is quite noticeable that the ranker-growing varieties with strong, stiff straw are the least affected. Then, too, among fall wheats in the northern part of the country it is quite essential that a wheat plant be able to send out tillers from the old roots of plants killed by the fly (fig. 10), and that these tillers prove hardy enough to withstand the winter. Therefore, in selecting varieties of wheat with a view to evading Hessian-fly attack, the farmer will do well to ignore statements on this point from those who have seed to sell and select from the varieties known to do well in his locality such as are of strong, vigorous growth, hardy, and with a stiff straw. For some reason the durum or macaroni wheats do not seem to attract the fly, at least not the second brood. In going over fields of this kind of wheat in sections where other spring wheats were suffering from attack by this pest, it was rarely found on a stem of macaroni wheat, while any straws of other varieties growing from seed that had become intermixed were almost invariably infested. Whether this will hold good in case of the young plants it is as yet impossible to say, because of the difficulty of telling to what varieties the young plants belong. Infested plants have been found in fields of young macaroni wheat in some considerable numbers; but these plants may have been of other varieties, as the fields had been used for other varieties the year before, and besides the seed itself may have been impure.

METEOROLOGICAL EFFECTS.

All who have carefully studied the Hessian fly, under various field conditions during a series of years, have noted that weather conditions have an important influence on the insect. Especially is this true in its economic relations to the grains it attacks; hence, in the application of preventive measures, these weather conditions become of vital importance.

Many farmers place much stress on the effect of cold weather or even of frosts in terminating the flies' work in the fall, and it is for this reason that many try to delay wheat sowing until after there has been a sharp frost. The facts are that the females will be abroad and ovipositing in freezing weather, and Mr. W. J. Phillips has found by experimentation that the eggs will remain in a temperature of 36° F. for seventy-two hours with no other effect than to delay their hatching that much longer. This is about the temperature at which

frosts would occur. Indeed, the writer has observed eggs hatching during the day in the fields when there were frosts nearly every night. Whether or not the larvæ from these would get sufficiently advanced to pass the winter would, of course, depend upon later weather conditions. In the North these much-belated larvæ are killed off by cold weather.

The immunity of the late-sown wheat from attack by the fly is not due to frost, but to the fact that, by the time severe frosts usually occur, most of the flies have appeared and gone.

The most marked influence of climatic conditions on this insect is seen in the effect of heat and drought, and especially of the two combined. In the South it is the long summer that so widely separates the two broods. Drought has a similar effect on the development of the insect as it has on the germination of the seed which produces its food; thus, dry weather in the late summer and fall tends to keep the insect in the flaxseed stage—a fact of special importance in the North, where it is imperative to get the wheat sown early enough to enable the plants to stand the winter. Under exceptional conditions, such as in a dry room, flaxseeds may be kept for a year, or even two, but when moistened the flies will soon after emerge. So in the fields they will, during a drought, remain in the flaxseed state for a considerable time after they would appear under normal conditions, and only appear soon after rains have moistened the soil.

NATURAL ENEMIES.

There can be no doubt that parasites play a most conspicuous part in the natural control of the Hessian fly, and if we only knew the whole truth of the matter we should find that these minute friends of the farmer are worth many times their weight in gold. Not infrequently one species of these parasites will overcome the pest in a neighborhood so effectively as almost to exterminate it. Several times the writer has found, in attempting to breed Hessian fly from young wheat plants that had been killed by the larvæ, that hundreds of these parasites would emerge from the flaxseeds, while only an occasional fly could be obtained. Nearly all of these deposit their eggs in the bodies of the maggots, but the fully developed parasites emerge from the flaxseeds.

Professor Osborn ^a has enumerated six species of these parasites, not including the English species *Entedon epigonus* Walker. *Polygnotus minutus* Lindm., which occurs in Russia, France, and England, is in

^a 1898: Bul. 16, n. s., Div. Ent., U. S. Dept. Agric., pp. 28-29.

America represented by *Polygnotus hiemalis* Forbes (fig. 11), perhaps the most useful of any in this country. It is very minute, and Mr. Reeves has counted over forty of the larvæ within a single flaxseed. It is black, with yellow feet, and the legs are dark brown, banded with yellow. The writer has again and again reared this in great numbers from fall wheat infested by the fly and witnessed the sudden check sustained by the pest the following spring. It



FIG. 11.—*Polygnotus hiemalis*, much enlarged (original).

is owing to this more than to any other influence that the Hessian fly is now being held in check in the spring wheat regions of the Northwest. Perhaps the next most useful parasite is *Eupelmus allynii* French (figs. 12, male, and 13, female). This is generally distributed over the country and affects both the Hessian fly and the joint-worm. It is larger than the preceding; the body is black, with a greenish luster, and the legs are more or less yellow. *Merisus destructor* Say (fig. 14) occurs in Europe, England, and America, but not in such profusion with us as to afford the same relief to the farmer as



FIG. 12.—*Eupelmus allynii*: Male, much enlarged (from Riley).

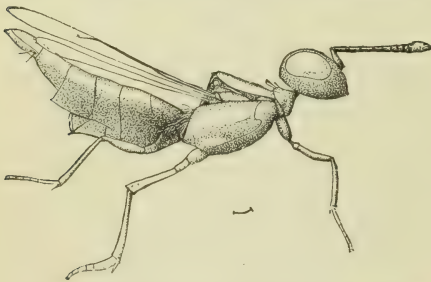


FIG. 13.—*Eupelmus allynii*: Female, much enlarged (from Riley).

in the case of the two preceding. It also is black, but with a bluish green metallic reflection, and the legs are black, banded with yellow. *Platygaster herrickii* Pack. (fig. 15) is very minute, shining black in color, and is supposed by many to attack the egg of the fly, but there is still some doubt regarding this. *Bæotomus subapterus* Riley (fig. 16), as the name implies, has aborted wings

in some individuals, while others are fully winged. The head and thorax are of a dark greenish metallic luster, and the legs honey-

ellow. It is generally less abundant than some of the others, but sometimes individuals are quite numerous. Besides these, several undescribed species have been recorded from the northwestern part of the country. The influence of these minute parasites in regulating the world's wheat supply is not at all understood, and it is doubtful if wheat could be successfully raised were they all to be suddenly swept out of existence.

REMEDIAL AND PREVENTIVE MEASURES.

Of remedies there is little to be said, since after the pest becomes



FIG. 14.—*Merisus destructor*, much enlarged (from Riley).

established in a field it can not be reached by any measure likely to destroy it. The application broadcast of some quick-acting fertilizer containing a large percentage of phosphate, made as soon as general infestation is apparent (see fig. 10), will cause the plants to tiller more freely and give them sufficient vigor to withstand the winter, and thus increase the number of healthy stems the following spring. Any other means that

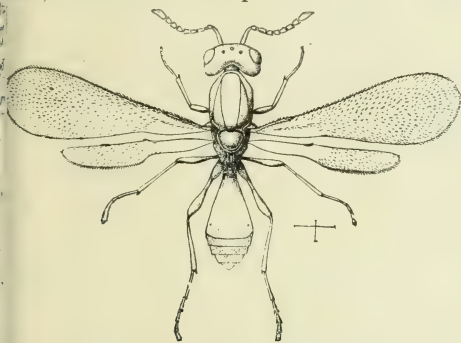


FIG. 15.—*Platygaster herrickii*, much enlarged (from Riley).

could be employed having a similar effect would be a remedial measure.

All practical measures must necessarily be in the nature of preventives, looking (1) to the elimination of the pest in the young wheat in the fall, and (2) to the increasing of the vigor of the young plants in order to enable them to counteract the insect's effect, when present. Under the first come late sowing, rotation of crops, burning of the old stubble, and the destruction of volunteer wheat. Under the second should be classed the enrichment of the soil, its thorough preparation, and selecting and properly sowing the best seed.

LATE SOWING.

By late sowing as here recommended is meant moderately late sowing of fall wheat in any locality, for extremely late sowing, which has sometimes been advised, would be even worse than early sowing. The later appearance of the fly in the fall, as we pass from the north south-

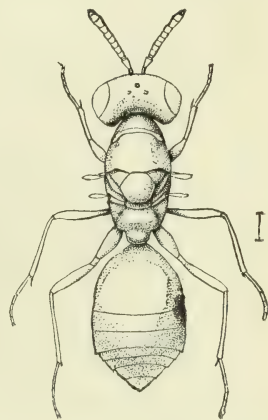


FIG. 16.—*Bæotomus subapterus*, much enlarged (from Riley).

ward, has already been explained. At present the Bureau of Entomology is conducting experiments in fall wheat sowing in nine States, covering approximately the country between latitude 33° and 46° . Here wheat is being sown every ten days during September, October, and November, year after year, with the expectation of determining the approximate date of safety for seeding in the fall to evade attack of the fly. While these experiments have not been going on for a long enough time to give results sufficiently definite, covering all variations in the weather during these months, it is safe to say that wheat may probably be sown, without danger from Hessian fly attack, in northern Michigan soon after the first of September; in southern Michigan and northern Ohio, about September 20; in southern Ohio, after the first week in October; in Kentucky and Tennessee, October 10 to 20; in Georgia and South Carolina, October 25 to November 15. So far these dates are only approximate, and serve to show in a general way about the time when the fall brood of the fly will have largely disappeared over the wheat belt east of the Mississippi River. As the larger part of the fall brood appears and is gone within a week, it is possible for a farmer to so time his seeding as to avoid it, and this is by far the most practical and effective preventive measure that can be applied.

CROP ROTATION.

Aside from the general benefits to be derived from crop rotation, it compels the Hessian fly, when it emerges from the stubble in the fall (or spring in the Northwest) to travel a greater or less distance to reach young wheat plants.

If, during this season of migration, storms or heavy winds occur, these frail creatures will be driven about or beaten down until a comparatively small number survive to reach their destination. On the other hand, if they are not obliged to leave the field where they emerge, this mortality will be vastly lessened.

BURNING STUBBLE.

This is the most efficient measure of all, as fire will reach and destroy not only the Hessian fly but all other insects infesting the stubble, including the joint-worm. Unfortunately, it can not be generally carried out. Over a large portion of the Middle West timothy and clover are sown, either with the wheat or during late winter or early spring, and therefore stubble-ground can not be burned over. Fields not followed by grass or clover can usually be burned over if the grain is cut rather high at harvest and a mower is run over the field and the mown grass, weeds, and stubble allowed to dry for a few days just before the burning. This is much the more feasible measure in the Northwest, and ought to be more generally followed.

DESTRUCTION OF VOLUNTEER WHEAT.

Perhaps the importance of this measure is best illustrated by the condition frequently observed in fields of young wheat in the fall, where every volunteer plant is infested and the sown grain is entirely free from attack. The volunteer plants were above ground in time to enable the fly to deposit her eggs on them, with the result that large numbers of flaxseeds will go through the winter and the flies therefrom will deposit their eggs on the plants which constitute the crop itself. Thus the growth of volunteer plants menaces, to a certain degree, the crop of the following year, precisely as does a field sown too early more seriously menace adjoining fields that are uninfested in the fall. This destruction of volunteer plants by plowing, disking, or otherwise must take place before the larvæ have matured in order to be effective.

ENRICHING THE SOIL.

While it may seem "far fetched" to bring forward as a preventive measure the enrichment of the soil, a fertile soil will produce plants that will withstand with little injury attacks that will prove disastrous to plants growing on an impoverished or thin soil. This is because a fertile soil will enable an infested plant to tiller freely, and these tillers will have sufficient vitality to withstand the winter and send up head-producing stems in the spring. It is also chiefly on the thin or impoverished soils that the difficulty of sowing late enough to evade the fall attack and at the same time secure a growth sufficient to withstand the winter is encountered, and whatever can be done to obviate this difficulty will constitute a preventive measure.

PROPER PREPARATION OF THE SOIL.

It matters little whether a soil has much or little fertility if that fertility is bound up in clods or hard lumps out of reach of the rootlets of the young plants. Early plowing and thorough working and compacting of the soil will eliminate the lumps and clods and produce a finely pulverized, compact, moisture-conserving seed bed, from which, as soon as rootlets are sent out from the seed kernel, the shoot will begin to draw nourishment. This will give vigor to the plants and thus enable them, by freely tillering, to outgrow a light attack of the fly that otherwise might prove serious.

THE USE OF GOOD SEED.

When we come to consider the fact that the seed kernel contains, or should contain, sufficient nutriment to put out and sustain rootlets until these can begin to draw from the soil and thus support the stem, it will be seen at once that any deficiency in the seed will necessarily tend to weaken the plant at the very beginning of its existence. Thus

good seed becomes the first requisite in securing the healthy, vigorous plant that is to be further strengthened and sustained by a well-prepared, fertile soil. It is very clear, then, that all shrunken, dwarfed, or otherwise imperfect kernels should be cleaned out of the seed before it is sown and only the largest and most perfect retained.

CONCLUSION.

Methods for controlling the Hessian fly, the worst pest of the wheat field, in the fall wheat growing sections, may be summarized as follows: Sow the best of seed in thoroughly prepared, fertile soil after the major portion of the fall brood has made its appearance and passed out of existence, and, if possible, sow on ground not devoted to wheat the preceding year.

In the spring-wheat section late seeding will not apply. It seems likely, on the contrary, that the earlier it is sown in spring the less it will suffer from the Hessian fly. But good seed and a well-prepared, fertile soil are as essential there as elsewhere.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *April 14, 1906.*

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United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

HOUSE FLIES.

(Musca domestica et al.)

By L. O. HOWARD.

There are several species of flies which are commonly found in houses, although but one of these should be called the house fly proper. This is the *Musca domestica* L. (fig. 1) and is a medium-sized, grayish fly, with its mouth parts spread out at the tip for sucking up liquid substances. It breeds in manure and dooryard filth and is found in nearly all parts of the world. On account of the conformation of its mouth

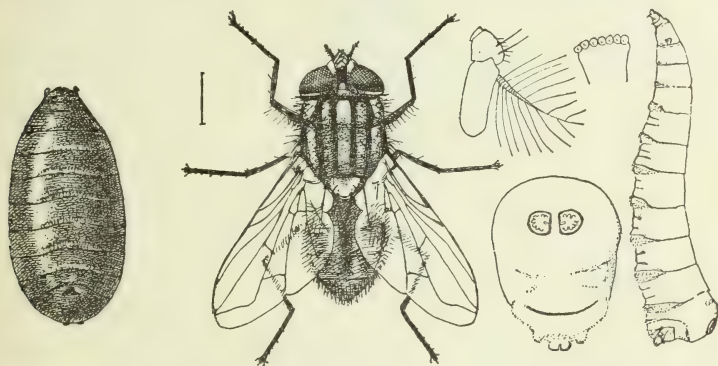


FIG. 1.—Common house fly (*Musca domestica*): Puparium at left; adult next; larva and enlarged parts at right. All enlarged (author's illustration).

parts, the house fly can not bite, yet no impression is stronger in the minds of most people than that this insect does occasionally bite. This impression is due to the frequent occurrence in houses of another fly (*Stomoxys calcitrans* L.) (fig. 2), which is called the stable fly, and which, while closely resembling the house fly (so closely, in fact, as to deceive anyone but an entomologist), differs from it in the important particular that its mouth parts are formed for piercing the skin. It is perhaps second in point of abundance to the house fly in most portions of the Northeastern States.

A third species, commonly called the cluster fly (*Pollenia rudis* Fab.), is a very frequent visitant of houses, particularly in the spring and fall. This fly is somewhat larger than the house fly, with a dark-colored, smooth abdomen and a sprinkling of yellowish hairs. It is not so active as the house fly and, particularly in the fall, is very sluggish. At such

times it may be picked up readily and is very subject to the attacks of a fungous disease which causes it to die upon window panes, surrounded by a whitish efflorescence. Occasionally this fly occurs in houses in such numbers as to cause great annoyance, but such occurrences are comparatively rare.

A fourth species is another stable fly, known as *Muscina stabulans* Fall. (fig. 3), a form which almost exactly resembles the house fly in general appearance, and which does not bite as does the biting stable fly. It breeds in decaying vegetable matter and in excrement.

Several species of metallic greenish or bluish flies are also occasionally found in houses, the most abundant of which is the so-called blue-bottle fly (*Calliphora erythrocephala* Meig.). This insect is also called the blow-fly or meat-fly and breeds in decaying animal material. A smaller species, which may be called the small blue-bottle fly, is *Phormia*

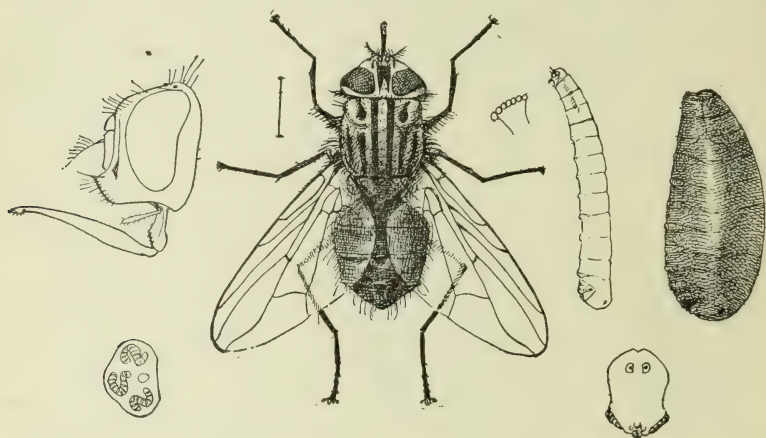


FIG. 2.—*Stomoxys calcitrans*: Adult, larva, puparium, and details. All enlarged (author's illustration).

terrænovæ Desv. (fig. 4); and a third, which is green in color and about the size of the large blue-bottle, is *Lucilia cæsar* L. (fig. 5).

There is still another species, smaller than any of those so far mentioned, which is known to entomologists as *Homalomyia canicularis* L., sometimes called the small house fly. A related species, *H. brevis* Rond., is shown in figure 6. *H. canicularis* is distinguished from the ordinary house fly by its paler and more pointed body and conical shape. The male, which is much commoner than the female, has large pale patches at the base of the abdomen, which are translucent when the fly is seen on a window pane. It is this species that is largely responsible for the prevalent idea that flies grow after gaining wings. Most people think that these little Homalomyias are the young of the larger flies, which, of course, is distinctly not the case.

Still another fly, and this one is still smaller, is a jet-black species known as the window fly (*Scenopinus fenestralis* L.), which in fact has

become more abundant of later years. It breeds in the dust under carpets, and its larva is a white, very slender, almost thread-like creature.

In the autumn, when fruit appears on the sideboard, many specimens of a small fruit-fly (*Drosophila ampelophila* Loew) (fig. 7) make their appearance, attracted by the odor of overripe fruit.

A small, slender fly is not infrequently seen in houses, especially upon window panes. This is *Sepsis violacea* Meig., shown enlarged in figure 8.

All of these species, however, are greatly dwarfed in numbers by the common house fly. In 1900 the writer made collections of the flies in dining rooms in different parts of the country, and out of a total of 23,087 flies 22,808 were

Musca domestica, that is, 98.8

per cent of the whole number captured. The remainder, consisting of 1.2 per cent of the whole, comprised various species, including those mentioned above.

LIFE HISTORY OF THE TRUE HOUSE FLY.

Musca domestica commonly lays its eggs upon horse manure. This substance seems to be its favorite larval food. It will oviposit on cow ma-

nure, but we have not been able to rear it in this substance. It will also breed in human excrement, and from this habit it becomes very dangerous to the health of human beings, carrying, as it does, the germs of intestinal diseases such as typhoid fever and cholera from excreta to food supplies. It will also lay its eggs upon other decaying vegetable and animal material, but of the flies that infest dwelling houses, both in cities and on farms, a vast proportion comes from horse manure.

At Salem, Mass., Packard states that he bred a generation in fourteen days in horse manure. The duration of the egg state was twenty-



FIG. 3.—*Muscina stabulans*, enlarged (author's illustration).



FIG. 4.—*Phormia terranova*, enlarged (author's illustration).



FIG. 5.—*Lucilia caesar*, enlarged (author's illustration).

four hours, the larval state from five to seven days, and the pupal state from five to seven days. At Washington the writer has found in mid-summer that each female lays about 120 eggs, which hatch in eight hours, the larva period lasting five days and the pupa five days, making the total time for the development of the generation ten days. This was at the end of June. The periods of development vary with the climate and with the season, and the insect hibernates in the puparium condition in manure or at the surface of the ground under a manure heap. It also hibernates in houses as adult, hiding in crevices.

The Washington observations indicate that the larvæ molt twice, and that there are thus three distinct larval stages.

The periods of development were found to be about as follows: Egg from deposition to hatching, one-third of a day; hatching of larva to

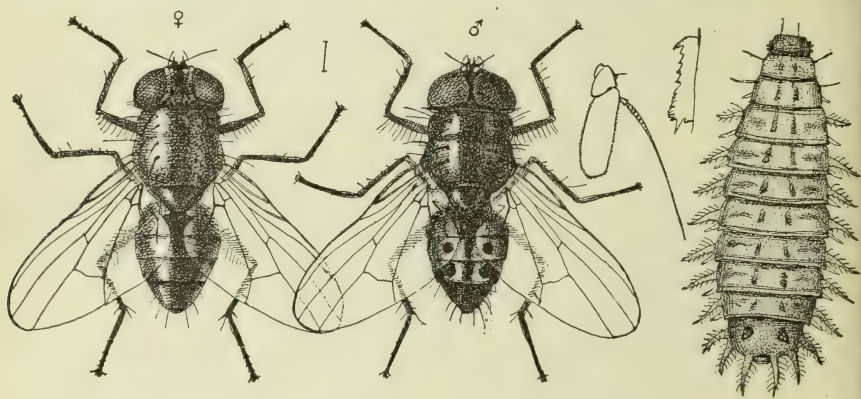


FIG. 6.—*Homalomyia brevis*: Female at left; male next, with enlarged antenna; larva at right. All enlarged (author's illustration).

first molt, one day; first to second molt, one day; second molt to pupation, three days; pupation to issuing of the adult, five days; total life round, approximately ten days. There is thus abundance of time for the development of twelve or thirteen generations in the climate of Washington every summer.

The number of eggs laid by an individual fly is undoubtedly large, averaging about 120, and the enormous numbers in which the insects occur is thus plainly accounted for, especially when we consider the abundance and universal occurrence of appropriate larval food. In order to ascertain the numbers in which house-fly larvæ occur in horse-manure piles, a quarter of a pound of rather well-infested horse manure was taken on August 9, and in it were counted 160 larvæ and 146 puparia. This would make about 1,200 house flies to the pound of manure. This, however, can not be taken as an average, since no larvæ are found in perhaps the greater part of ordinary horse-manure piles. Neither, however, does it show the limit of what can be found, since about 200 puparia were found in less than 1 cubic inch of manure taken

from a spot 2 inches below the surface of the pile where the larvæ had congregated in immense numbers. The different stages of the insect are well illustrated in figure 1 and need no description.

REMEDIES AND PREVENTIVES.

A careful screening of windows and doors during the summer months, with the supplementary use of sticky fly papers, is a preventive measure against house flies known to everyone, and there seems to be little hope in the near future of much relief by doing away with the breeding places. A single stable in which a horse is kept will supply house flies for an extended neighborhood. People living in agricultural communities will probably never be rid of the pest, but in cities, with better methods of disposal of garbage and with the lessening of the number of horses and horse stables consequent upon electric street railways, bicycles, and automobiles, the time may come, and before very

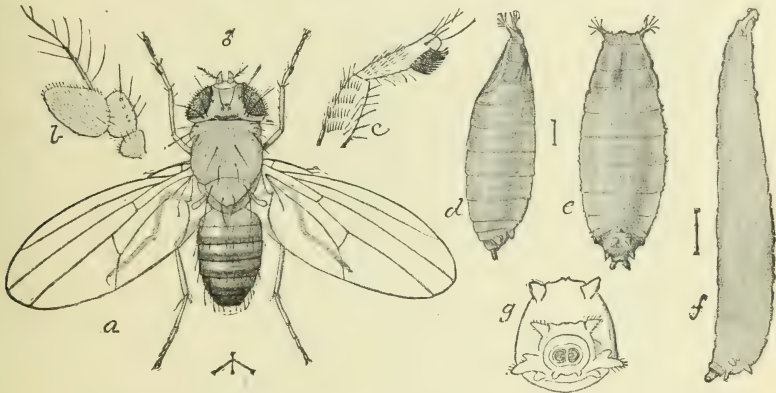


FIG. 7.—*Drosophila ampelophila*: a, adult; b, antenna of same; c, base of tibia and first tarsal joint of same; d, puparium, side view; e, puparium from above; f, full-grown larva; g, anal spiracles of same. All enlarged (author's illustration).

long, when window screens may be discarded. The prompt gathering of horse manure, which may be variously treated or kept in a specially prepared receptacle, would greatly abate the fly nuisance, and city ordinances compelling horse owners to follow some such course are desirable. Absolute cleanliness, even under existing circumstances, will always result in a diminution of the numbers of the house fly, and, in fact, most household insects are less attracted to the premises of what is known as the old-fashioned housekeeper than to those of the other kind.

During the summer of 1897 a series of experiments was carried out with the intention of showing whether it would be possible to treat a manure pile in such a way as to stop the breeding of flies. The writer's experience with the use of air-slaked lime on cow manure to prevent the breeding of the horn fly suggested experimentation with different

lime compounds. It was found to be perfectly impracticable to use air-slaked lime, land plaster, or gas lime with good results. Few or no larvæ were killed by a thorough mixing of the manure with any of these three substances. Chlorid of lime, however, was found to be an excellent maggot killer. Where 1 pound of chlorid of lime was mixed with 8 quarts of horse manure, 90 per cent of the maggots were killed in less than twenty-four hours. At the rate of a quarter of a pound of chlorid of lime to 8 quarts of manure, however, the substance was found not to be sufficiently strong. Chlorid of lime, though cheap in Europe, costs at least $3\frac{1}{2}$ cents a pound in large quantities in this country, so that the frequent treatment of a large manure pile with this substance would be out of the question in actual practice.

Experiments were therefore carried on with kerosene. It was found

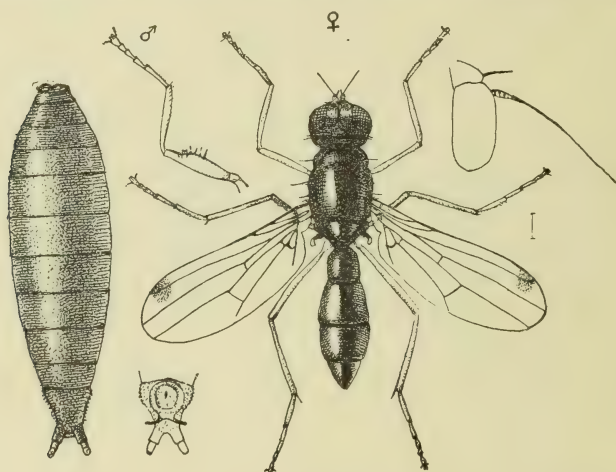


FIG. 8.—*Sepsis violacea*: Adult with enlarged antenna at right; puparium at left. All enlarged (author's illustration).

that 8 quarts of fresh horse manure sprayed with 1 pint of kerosene, which was afterwards washed down with 1 quart of water, was thoroughly rid of living maggots. Every individual was killed by the treatment. This experiment and others of a similar nature on a small scale were so satisfactory that it was considered at the close of the season that a practical conclusion had been reached, and that it was perfectly possible to treat any manure pile economically and in such a way as to prevent the breeding of flies.

Practical work in the summer of 1898, however, demonstrated that this was simply another case where an experiment on a small scale has failed to develop points which in practical work would vitiate the results.

The stable of the U. S. Department of Agriculture, in which about twelve horses are kept, is situated about 100 yards behind the main building of the Department and about 90 yards from the building in

which the Bureau of Entomology is situated. This stable has always been very carefully kept. The manure was thoroughly swept up every morning, carried outside of the stable, and deposited in a pile behind the building. This pile, after accumulating for a week or ten days, or sometimes two weeks, was carried off by the gardeners and spread upon distant portions of the grounds. At all times in the summer this manure pile swarmed with the maggots of the house fly. It is safe to say that on an average many thousands of perfect flies issued from it every day, and that at least a large share of the flies which constantly bothered the employees in the two buildings mentioned came from this source.

On the basis of the experiments of 1897, an attempt was made, beginning early in April, 1898, to prevent the breeding of house flies about the Department by the treatment of this manure pile with kerosene. The attempt was begun early in April and was carried on for some weeks. While undoubtedly hundreds of thousands of flies were destroyed in the course of this work, it was found by the end of May that it was far from perfect, since if used at an economical rate the kerosene could not be made to penetrate throughout the whole pile of manure, even when copiously washed down with water. A considerable proportion of house-fly larvæ escaped injury from this treatment, which at the same time was found, even at an economical cost, to be laborious, and such a measure, in fact, as almost no one could be induced to practically adopt.

There remained, however, another measure which had been suggested by the writer in an article on the house fly published in 1895, namely, the preparation of an especial receptacle for the manure, and this was very readily accomplished. A closet 6 by 8 feet had been built in the corner of the stable nearest the manure pile. It had a door opening into the stable proper, and also a window. A door was built in the outside wall of this closet, and the stablemen were directed to place no more manure outside the building; in other words, to abolish the outside manure pile, and in the future to throw all of the manure collected each morning into this closet, the window of which in the meantime had been furnished with a wire screen. The preparations were completed by the middle of June, and a barrel of chlorid of lime was put in the corner of the closet. Since that time every morning the manure of the stable is thrown into the closet, and a small shovelful of chlorid of lime is scattered over it. At the expiration of ten days or two weeks the gardeners open the outside door, shovel the manure into a cart, and carry it off to be thrown upon the grounds.

Judging from actual examination of the manure pile, the measure is eminently successful. Very few flies are breeding in the product of the stable which formerly gave birth to many thousands daily. After this measure had been carried on for two weeks, employees of the Depart-

ment who had no knowledge of the work that was going on were asked whether they had noticed any diminution in the number of flies in their offices. Persons in all of the offices on the first floor of the two buildings were asked this question. In every office except one the answer was that a marked decrease had been noticed, so that the work must be considered to have been successful.

The account of this remedial work has been given with some detail, since it shows so plainly that care and cleanliness combined with such an arrangement as that described will in an individual stable measurably affect the fly nuisance in neighboring buildings.

With the combined efforts of the persons owning stables in a given community, much more effective results can undoubtedly be gained.

In the consideration of these measures we have not touched upon the remedies for house flies breeding in human excrement. On account of the danger of the carriage of typhoid fever, the dropping of human excrement in the open in cities or towns, either on vacant lots or in dark alleyways, should be made a misdemeanor, and the same care should be taken by the sanitary authorities to remove or cover up such depositions as is taken in the removal of the bodies of dead animals. The box privy is always a nuisance from many points of view and is undoubtedly dangerous as a breeder of flies which may carry the germs of intestinal disease. No box privies should be permitted to exist unless they are conducted on the earth-closet principle. With a proper vault or other receptacle, closed except from above, and a free use of fine earth, the breeding of house flies can be prevented. Covering the surface with lime, however, is more certain than the use of earth. The writer has seen, in a large camp of volunteer soldiery, unprotected sinks in which the house fly was breeding by the thousands. He has also seen permanent camps in which the sinks were so constructed and so treated with lime that no house flies whatever were present.

A Parisian journal, the *Matin*, during the winter of 1905-6, established a prize of 10,000 francs for the best essay on the destruction of the house fly. The jury of competent scientific men awarded the prize to the author of a memoir in which it was proposed to use residuum oil in the destruction of the eggs and larvæ of the fly. This oil is to be used in privies and cesspools. Two liters per superficial meter of the pit is mixed with water, stirred with a stick of wood, and then thrown into the receptacle. It is said to form a covering of oil which kills all the larvæ, prevents the entrance of flies into the pit and, at the same time, the hatching of eggs. It makes a protective covering for the excrement, and this is said to hasten the development of anaerobic bacteria as in a true septic pit, leading in this way to the rapid liquefaction of solid matters and rendering them much more unfit for the development of other bacteria. For manure it is recommended to mix this residuum oil with earth, with lime, and with phosphates, and to spread it at

different times, in the spring by preference, upon the manure of farms and stables and so on.

Practical experimentation with this proposed remedy will be undertaken the coming spring in France.

NATURAL ENEMIES.

The house fly has a number of natural enemies. The common house centipede (fig. 9) destroys it in considerable numbers, there is a small reddish mite which frequently covers its body and gradually destroys it, it is subject to the attacks of hymenopterous parasites in its larval condition, and it is destroyed by predatory beetles at the same time.

The most effective enemy, however, is a fungous disease known as *Empusina muscæ*, which carries off flies in large numbers, particularly toward the close of the season. The epidemic ceases in December, and although many thousands are killed by it, the remarkable rapidity

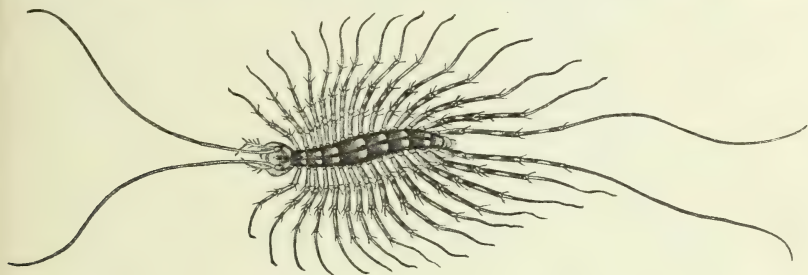


FIG. 9.—*Scutigera forceps*: Adult, natural size (after Marlatt).

of development in the early summer months soon more than replaces the thousands thus destroyed.

WHAT CITIES AND TOWNS CAN DO.

It would appear, from what we know of the life history of the common house fly and from what remedial experimentation has already been carried on, that it is perfectly feasible for cities and towns to so greatly reduce the numbers of these annoying and dangerous insects as to render them of comparatively slight account. The health departments of most of our cities have the authority to abate nuisances dangerous to health, and it is easy for the health authorities of any city to formulate rules concerning the construction and care of stables and the keeping and disposal of manure which, if enforced, will do away with the house-fly nuisance. Such a series of rules was formulated in the spring of 1906 by the Health Department of the city of Asheville, N. C., and an effort is being made during this summer to see that they are enforced. On the 3d of May, 1906, the Health Department of the District of Columbia also issued a series of orders of this nature, on the authority

of the Commissioners of the District, and these orders, which may well serve as a model to other communities desiring to undertake similar measures, may briefly be condensed as follows:

All stalls in which animals are kept shall have the surface of the ground covered with a water-tight floor. Every person occupying a building where domestic animals are kept shall maintain, in connection therewith, a bin or pit for the reception of manure, and, pending the removal from the premises of the manure from the animal or animals, shall place such manure in said bin or pit. This bin shall be so constructed as to exclude rain water, and shall in all other respects be water-tight except as it may be connected with the public sewer. It shall be provided with a suitable cover and constructed so as to prevent the ingress and egress of flies. No person owning a stable shall keep any manure or permit any manure to be kept in or upon any portion of the premises other than the bin or pit described, nor shall he allow any such bin or pit to be overfilled or needlessly uncovered. Horse manure may be kept tightly rammed into well-covered barrels for the purpose of removal in such barrels. Every person keeping manure in any of the more densely populated parts of the District shall cause all such manure to be removed from the premises at least twice every week between June 1 and October 31, and at least once every week between November 1 and May 31 of the following year. No person shall remove or transport any manure over any public highway in any of the more densely populated parts of the District except in a tight vehicle which, if not inclosed, must be effectually covered with canvas, so as to prevent the manure from being dropped. No person shall deposit manure removed from the bins or pits within any of the more densely populated parts of the District without a permit from the health officer. Any person violating any of the provisions shall, upon conviction thereof, be punished by a fine of not more than \$40 for each offense.

As with all such measures, the test comes with the enforcement, and during the present summer these regulations have not been well enforced, owing to the extremely small corps of inspectors allowed to the Health Department, and to other more pressing work. They can be made effective, however, and it is earnestly hoped that not only Washington but other communities as well will very soon be brought to a realization of the ease of house-fly eradication and its very great desirability.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *September 21, 1906.*

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

KEY TO THE KNOWN LARVÆ OF THE MOSQUITOES OF THE UNITED STATES.¹

By HARRISON G. DYAR.

1. Larvæ without a distinct air tube, the air hole with flaps but no elongated sides; floating at surface of water in a horizontal position. The malaria carriers ----- Subfamily ANOPHELINÆ ---- 3
 Larvæ with a distinct elongated air tube; floating below the surface of water, usually obliquely, hanging by the tube ----- 2
2. The last segment, beyond the air tube, with a ventral brush or rudder in the middle of the segment behind ----- Subfamily CULICINÆ ---- 6
 Last segment without a median brush, the hairs paired on the two sides, none on mid-ventral line ----- Subfamily SABETHINÆ.
 Only one species, in leaves of pitcher plants in cold bogs.
Wyeomyia smithii Coquillett.
3. Abdomen with plumose lateral hairs on the first three segments only; head with plumose hairs ----- 4
 Abdomen with plumose hairs to the sixth segment; head without plumose hairs. Lives in hollow trees ----- *Anopheles barberi* Coquillett.
4. Lateral comb (on the eighth segment below the air hole) with one long lower tooth followed by *four* little ones ---- *Anopheles franciscanus* McCracken.
 Lateral comb with one long lower tooth followed by *three* little ones.
Anopheles punctipennis Say.
 Lateral comb with the lower long tooth followed by another as long or nearly so ----- 5
5. Lateral comb with the upper tooth short. *Anopheles maculipennis* Meigen.
 Lateral comb with the upper tooth long ---- *Anopheles crucians* Wiedemann.
6. Mouth brush folded outward when not in use, not vibratile, used to seize prey only. Predaceous on other mosquito larvæ ----- 7
 Mouth brush folding inward, tufted, vibratile, usually continually in motion. Feed on microscopic organisms and vegetable detritus ----- 9
7. A plate on the side on the eighth abdominal segment. Only one species, living in hollow trees and water barrels; beneficial.
Megarhinus portoricensis von Röder.
 A patch of small scales on the side of the eighth abdominal segment. Living in temporary puddles; beneficial species ----- 8
8. Labial plate (mentum) of head with the teeth regular and alike.
Psorophora ciliata Fabricius.
 Labial plate with the next to the basal tooth much enlarged.
Psorophora howardii Coquillett.

¹ The generic names here used have been made uniform with those of Technical Series No. 11, of this Bureau, to facilitate cross reference. In case of discrepancy in specific names, the names employed in that publication are given in footnotes.

9. Antennæ with tuft outwardly placed, in a notch, the apical part of antenna slender; air tube long, over three times as long as wide 10
 Antennæ with the tuft at or before the middle, the apical part not more slender; air tube usually shorter than three times its width 17
 10. Lateral comb of the eighth segment a patch of spines 11
 Lateral comb of the eighth segment a row of bars 16

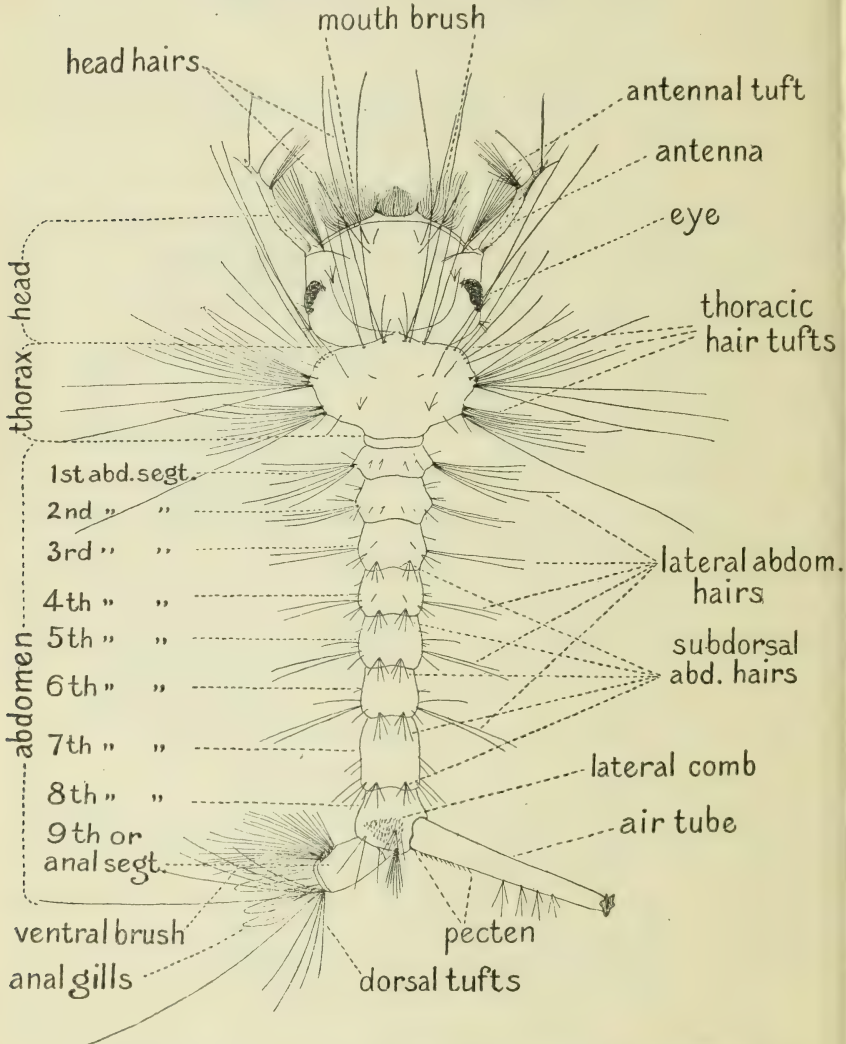


FIG. 1.—Diagram of a mosquito larva (*Culex salinarius*), with names of the parts referred to in the key (original).

11. Anal segment with a row of hairs along the ventral line to base; an early spring species *Culicella dyari* Coquillett.
 Anal segment without any tufts in front of the ventral brush 12
 12. Air tube with four paired tufts posteriorly outwardly, the subapical one moved sideways out of line 13
 Air tube with four to ten paired tufts along the posterior line in a straight row, none displaced 15

13. Air tube over five times as long as wide, nearly straight, without marked tapering; living in fresh-water pools, rain barrels, etc.

Culex salinarius Coquillett.

Air tube less than five times as long as wide, tapering rather rapidly after the middle, somewhat fusiform in shape..... 14

14. Air tube five times as long as wide, its pecten of 15 teeth; subdorsal hairs of third and fourth abdominal segments double. Introduced domestic mosquito..... *Culex pipiens* Linnaeus.

Air tube four times as long as wide, its pecten of nine teeth; subdorsal hairs of the third and fourth abdominal segments single. Southern domestic mosquito..... *Culex fatigans* Wiedemann.¹

15. Air tube slightly expanded at tip. Summer swamp mosquito. The adult does not bite..... *Culex territans* Walker.

Air tube evenly tapered to tip. Living in permanent pools all summer.

Culex tarsalis Coquillett.

16. Bars of comb in a perfectly regular row; skin smooth. Hibernates as fully grown larva in permanent pools..... *Melanoconion melanurus* Coquillett.

Bars of comb in an irregular row; skin minutely pilose.

Mochlostyrax erraticus Dyar and Knab.²

17. Air tube strongly inflated; anal segment with a chitinous ring, pierced by a row of tufts along the ventral line..... 18

Air tube not inflated; anal segment not ringed, or, if so, without tufts along the ventral line..... 20

18. Antennæ long and prominent..... 19

Antennæ less long, moderate only. Developing rapidly in rain puddles.

Grabhamia jamaicensis Theobald.

19. Lateral comb of the eighth segment of six or seven nearly equal teeth.

Developing rapidly in rain puddles.. *Janthinosoma sayi* Dyar and Knab.³

Lateral comb of the eighth segment of five teeth, the upper and lower ones small..... *Janthinosoma varipes* Coquillett.

20. Antennæ inflated and bent. Rapidly developing in rain puddles.

Grabhamia discolor Coquillett.

Antennæ not markedly inflated or bent..... 21

21. Head with a lateral prominent angle which receives a process on the mandible. In crab holes on the Florida coast.. *Deinocerites cancer* Theobald.

Head without such an angle..... 22

22. Head with thick club-like hairs..... Genus *Uranotænia*.⁴

Head with the usual fine hairs only..... 23

23. Air tube without pecten; several chitinous plates on the abdominal segments. In hollow trees and rain barrels.. *Pneumaculex signifer* Coquillett.

Air tube with pecten; abdominal segments without any plates before the air tube..... 24

24. Air tube bottle-shaped, the outer half linear.

Teniorhynchus perturbans Walker.

Air tube regularly tapered..... 25

25. Air tube with a row of hairs beyond the pecten, the pair of tufts at base of tube..... 26

Air tube without a row of hairs; the tuft at or beyond the middle of the tube..... 28

¹ *Culex pipiens* (in part). Not the true *fatigans* of India, but so called by Theobald. The proper name of our species appears to be *Culex cubensis* Bigot.

² *Melanoconion atratus* (in part).

³ *Janthinosoma posticata*.

⁴ Three species differentiated by minute characters. Only one species is at all common, *Uranotænia sapphirina* Osten-Sacken.

26. Lower head tuft with three long hairs, the upper multiple. In permanent water, with a northern distribution..... *Culiseta absobrinus* Felt.
Lower and upper head tufts alike, multiple 27
27. Basal pecten teeth of the air tube with one branch. In pools, barrels, etc., with western distribution *Theobaldia incidens* Thomson.
Basal pecten teeth of air tube with several branches. In pools, with eastern and southern distribution *Culiseta consobrinus* Desvoidy.
28. Air tube with several hair tufts 29
Air tube with only one pair of tufts 30
29. Air tube long; anal segment with a complete ring. Living in pools and rain barrels *Culex restuans* Theobald.
Air tube short; anal segment not fully ringed. An early spring species.
Ochlerotatus trichurus Dyar.¹
30. Air tube with the hair tuft within the pecten 31
Air tube with the hair tuft beyond the pecten 33
31. Anal segment ringed with a horny plate 32
Anal segment not ringed. In pot holes in rocks.
Ochlerotatus atropalpus Coquillett.
32. Lateral comb of the eighth segment a few scales in a row. In swamps, with a southern distribution *Aedes tormentor* Dyar and Knab.²
Lateral comb of the eighth segment a large patch of scales.
Ochlerotatus bimaculatus Coquillett.
33. Pecten of the air tube with detached teeth outwardly 34
Pecten of the air tube with all the teeth evenly spaced 38
34. Air tube four times as long as wide; lateral comb of the eighth segment a patch of scales three rows deep. An early spring species.
Ochlerotatus abfitchii Felt.
Air tube three times as long as wide or less; lateral comb of the eighth segment of few scales 35
35. Antennæ enlarged basally; tuft rather beyond the middle. An early spring species *Ochlerotatus aurifer* Coquillett.
Antennæ moderate only; the tuft before the middle 36
36. The two rows of the pecten of the air tube approximate behind; dorsal plate of anal segment a saddle only. An early spring species.
Ochlerotatus impiger Walker.
The two rows of pecten well separated; dorsal plate more than half encircling the anal segment 37
37. Tuft of the tube before the outer third; anal gills blunt. In rain puddles.
Ochlerotatus sylvestris Theobald.
Tuft of tube beyond the outer third; anal processes pointed. In rain puddles.
Aedes fuscus Osten-Sacken.
38. Comb scales few, in a single or irregularly single row 39
Comb scales more numerous to many, in a patch 43
39. Anal segment ringed by the plate 40
Anal segment not completely ringed by the plate 42
40. Anal gills moderate, normal 41
Anal gills very long with stout central trachea. In pools, not coming to the surface; distribution southern *Ochlerotatus dupreei* Coquillett.
41. Pecten of air tube running about one-third; anal segment not longer than wide. An early spring species *Ochlerotatus punctor* Kirby.
Pecten of air tube running about one-half; anal segment longer than wide.
Aedes atlanticus Dyar and Knab.²

¹ *Ochlerotatus cinereoborealis*.² *Ochlerotatus serratus* (in part).

42. Scales of the comb of the eighth segment smooth, bluntly rounded. In hollow trees and rain barrels *Ochlerotatus triseriatus* Say.
Scales of comb sole-shaped with trifid apex. The yellow-fever mosquito. *Stegomyia calopus* Meigen.
43. Anal segment ringed by the plate 44
Anal segment not completely ringed by the plate 50
44. Air tube over twice as long as wide, its pecten of 19 to 22 teeth 45
Air tube twice as long as wide or less, its pecten of 12 to 14 teeth 48
45. Scales of the comb with the central spinule shorter than the body of the scale; pecten of the air tube of equal teeth 46
Scales of the comb with central spinule as long as the body of the scale; pecten of the air tube longer outwardly 47
46. Air tube two and one-half times as long as wide; comb scales moderate. The Atlantic coast salt-marsh mosquito. *Ochlerotatus sollicitans* Walker.
Air tube three times as long as wide; comb scales long. In rain puddles, with a southern distribution *Ochlerotatus mitchellæ* Dyar.
47. Air tube pecten reaching to beyond the middle of the tube; lateral comb of 21 scales in nearly three rows *Ochlerotatus trivittatus* Coquillett.
Air tube pecten not reaching to the middle of the tube; comb of 17 scales in two imperfect rows. An early spring species. *Ochlerotatus auroides* Felt.
48. Scales of the comb feathered on the sides, with central thorn. *Aedes infirmatus* Dyar and Knab.¹
Scales of the comb evenly feathered; no central thorn 49
49. Air tube one and one-half times as long as wide; pecten teeth broadly elliptical. In puddles along the Atlantic seaboard. *Ochlerotatus damnosus* Say.²
Air tube twice as long as wide; pecten teeth narrowly elliptical. An early spring species *Ochlerotatus inconspicuus* Grossbeck.
50. Air tube four times as long as wide; tracheæ narrow, angled. An early spring species *Ochlerotatus fitchii* Felt and Young.
Air tube three times as long as wide or less 51
51. Anal plate small; gills very large, sack like, spotted. *Ochlerotatus varipalpus* Coquillett.
Anal plate over half encircling the segment; anal gills moderate or small. 52
52. Comb scales tapered, a single median spinule stouter or larger than the rest 53
Comb scales bluntly rounded, the median spinule resembling the others. 59
53. Both of the hair tufts on the front of the head multiple 54
The lower head tuft single or double (rarely three) 56
54. Subdorsal prothoracic hairs single. In temporary pools. *Ochlerotatus canadensis* Theobald.
Ochlerotatus nivitarsis Coquillett.³
Subdorsal prothoracic hairs multiple 55
55. Weakly colored; tufts of ventral brush short-stemmed. In puddles near the sea along the Atlantic coast *Ochlerotatus cantator* Coquillett.
Darkly colored; tufts of the ventral brush long-stemmed. An early spring species in the Northwest *Ochlerotatus pullatus* Coquillett.
56. Lower head hair double (or triple) 57
Lower head hair single 58

¹ *Ochlerotatus confirmatus* (in part).² *Ochlerotatus tæniorhynchus*.³ Imperfectly known.

57. Comb scales with lateral spinules as long as the apical one. An early spring species----- *Aedes grossbecki* Dyar and Knab.¹
 Comb scales with the lateral spinules very short. An early spring species. *Ochlerotatus pretans* Grossbeck.
58. Apical spinule of the comb scale sharp and distinct An early species in the Northwest----- *Ochlerotatus aestivalis* Dyar.
 Apical spinule of comb scale not sharply distinct. An early spring species in the Northeast----- *Ochlerotatus subcantans* Felt.
59. Anal gills moderately long. An early spring species in the Northeast. *Ochlerotatus lazarensis* Felt.
 Anal gills very short, bud-shaped. The Pacific coast salt-marsh mosquito. *Aedes quaylei* Dyar and Knab.²

¹ *Lepidoplatus squamiger* (in part).

² *Ochlerotatus lativittatus*.

Approved:

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., April 27, 1906.

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE PLUM CURCULIO.

(Conotrachelus nenuphar Herbst.)

By FRED JOHNSON and A. A. GIRAULT,

Engaged in Deciduous-Fruit Insect Investigations.

INTRODUCTION.

The small, crescent-shaped punctures so commonly found on plums and other stone fruits in orchards east of the Rocky Mountains are made by a small snout-beetle of rough sculpture, known as the plum curculio. These beetles issue from their winter quarters about the time the trees are in bloom, and feed on the tender foliage, buds, and blossoms. Later they attack the newly set fruit, cutting small circular holes through the skin in feeding, while the females, in the operation of egg laying, make the crescentic cuts so characteristic of this species. The egg, deposited under the skin of the fruit, soon hatches into a very small whitish larva or grub, which makes its way into the flesh of the fruit. Here it feeds greedily and grows rapidly, becoming, in the course of a fortnight, the fat, dirty white "worm" so well known among fruit growers.



FIG. 1.—The plum curculio (*Conotrachelus nenuphar*): a, larva; b, adult; c, pupa. Much enlarged (hair line to right of b indicates natural length of adult). (From Chittenden.)

The plum curculio is a native of North America and for more than one hundred and fifty years has been known as an enemy of stone fruits. Our early horticultural literature abounds with references to its depredations. In more recent times the great increase in plantings of fruits, brought about to supply the increased demand, has permitted it to become much more abundant than formerly, and the plum curculio constitutes, at the present time, one of the most serious insect enemies of orchard crops.

This species is quite generally distributed over the United States eastward of about the one hundredth meridian, its range extending from

southern Canada to Florida and Texas. Westward of the States bordering the Mississippi River, it rapidly loses its importance as a pest, owing, probably, to the more arid condition of the climate.

LIFE HISTORY AND HABITS.

Like other beetles, the plum curculio has four distinct stages in its life, namely, the egg, the larva or "worm," the pupa, and the adult or beetle. The last three stages are shown much enlarged in figure 1.

The insect passes the winter in the adult or beetle stage under accumulations of partly decayed leaves, among the closely packed dried grass of sod-covered orchards, and probably wherever suitable protection from the weather may be found. As its depredations are usually the worst in those portions of orchards which are in close proximity to woods, the beetles doubtless find the natural accumulations of rubbish in such situations very suitable places in which to pass the winter.



FIG. 2.—The plum curculio: Adult female on plum, showing the circular feeding punctures and the crescentic egg-laying punctures. Enlarged (original).

In Niagara County, N. Y., during the fall of 1905, numerous careful searches for beetles were made under leaves and rubbish in plum, peach, and apple orchards, and woodlots and hedgerows adjoining them. These searches did not discover any hibernating beetles except in one large apple orchard where the ground was covered with sod. Failure to find beetles in other places was probably due to the scarcity of the insect in plum and peach orchards during the preceding summer. In the sod-covered apple orchard mentioned, a total of 42 beetles was found at various times between October 14 and November 28. In every case they were beneath partly decayed leaves under apple trees and often in depressions in the soil into which the leaves were closely packed.

In the spring, when the fruit buds are unfolding, the beetles begin to emerge from their winter quarters and feed to some extent on the blossoms and tender leaves. Mating soon begins, and by the time the fruit is well set the beetles make this fruit the chief object of their attention. Figure 2 is an enlarged illustration of a young plum, showing a female beetle and the characteristic feeding and egg-laying punctures which she has been engaged, with others, in making. The circular punctures are those made in feeding; the others are egg punctures.

A single egg is deposited in a puncture, although several may be placed in a single fruit. From one to eight eggs may be deposited daily by an individual female. Oviposition and feeding continue for several

weeks and in the case of the hardier individuals may extend over a period of several months. Egg laying is, however, most active during the first four or five weeks after emergence of the beetles in spring.

During recent years egg-laying records for the season, made in widely separated localities, show that the total number of eggs deposited by the female varies widely. In Maryland Professor Quaintance and Mr. R. I. Smith found that the number deposited in plums by females of longest life varied from 276 to 436. At Washington, D. C., the junior author during the past season obtained records of oviposition in plums which showed a range of from 273 to 560. A record of egg deposition in plums was also made by the senior author in western New York during the same season, and this showed a range of from 76 to 254. Professor Crandall, in Illinois, obtained records for apples showing a range of from 18 to 252 for individuals of longest life. The number of days required for the eggs to hatch varies according to temperature. Records of the past season show that at Washington, D. C., the time varies from about three to five days, whereas in western New York it varies from about four to seven days.

When the larva obtains full growth, which requires some twelve to eighteen days, it bores its way out of the fruit and enters the soil. At a depth varying from one-half inch to 2 inches, rarely much deeper, it forms an earthen cell in which to pupate. The time required for the pupal stage and the emergence of the normally colored beetle is from three to four weeks. Thus the period of development from egg to adult is covered in from about five to seven weeks. Differences in weather and soil conditions, however, cause the time of emergence of the adults to vary greatly. When the soil is very dry, the beetles may remain in the pupal cell for days or even weeks after their normal period of emergence, whereas after a heavy rain they may emerge in numbers. Thus a new generation of beetles from eggs deposited early in the season appears some time before all the parent beetles have died. In fact, some of the overwintering beetles have been kept alive until late in October.

Upon emergence from the soil, beetles of the new generation almost immediately turn their attention to ungathered fruit, if this be present on the trees. In Georgia peach orchards, as observed by Mr. J. H. Beattie, of this Bureau, the beetles attack the foliage in cases where the fruit has been harvested. Prunes, plums, and peaches often suffer severely, and the injury is familiar to many orchardists as the circular punctures and pits made at the stem end of the fruits, causing the latter to rot and drop off a few days before ripening. The work of the new generation of the curculio is conspicuous on late varieties of apples also, the beetles feeding upon these until the approach of cold weather, when they leave the trees and seek winter quarters. In orchards where sod and other conditions permit the accumulation of leaves and rubbish

directly beneath the trees many beetles simply go to the ground, work beneath the leaves, and there pass the winter, and are thus near at hand to attack the fruit when it develops the following spring.

FOOD PLANTS.

The natural food plant of the plum curculio is undoubtedly the native wild plum. The curculio also feeds upon and breeds in wild crabapples, wild cherries, and haws, and is reported to breed in the persimmon. It has also been bred from a common fungous growth of plums and cherries called "black-knot" (*Plowrightia morbosa* Sacc.), though this is evidently an abnormal habit. Of the cultivated pome and stone fruits, nearly all are attacked for feeding and egg-laying purposes, including plums, peaches, cherries, nectarines, apricots, apples, and pears, but of those listed the smooth-skinned sorts, notably plums, are preferred. The beetle feeds also upon the blossoms and foliage of its various food plants, but to a much more limited extent.

CHARACTER OF INJURY.

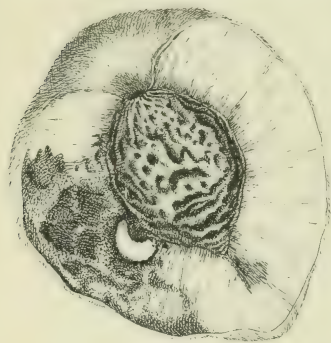


FIG. 3.—Nearly full-grown larva of the plum curculio in a ripe peach, showing injury to the interior of the fruit. Somewhat reduced (original).

The plum curculio is injurious in both the larval and adult stages, though it is in the adult stage that it is most harmful. The young fruit becomes badly scarred by the more or less crescentic egg punctures and pit-like feeding punctures, and in late summer and fall fruit is injured by the feeding of beetles of the new generation. The presence of the larva in the young fruit generally causes it to fall, and in cherries and nearly ripe peaches and plums in which it may develop the fruit is

spoiled. (See figure 3, showing injury of this character to a ripe peach.) The character of injury varies somewhat according to the kind of fruit and for this reason is best discussed under separate headings.

Plum.—The plum is undoubtedly the favorite food of this insect and accordingly suffers severe injury when the curculio is abundant. Eggs are deposited in the young fruit, and this may soon fall to the ground, a result of injury caused by the young larvæ. In seasons of short crops very little fruit may remain to ripen. With varieties which are inclined to overbear in seasons of very heavy crops, however, this kind of work may result in much good by thinning the crop. As the fruit becomes larger the many egg and feeding punctures which it has received cause it to become misshapen and to exude masses of gum. When the plums become of some size and are growing rapidly, the larvæ are apparently not able to develop, but when the fruit is nearly mature and softer they are better able to survive, and thus ripe fruit on the trees is often

"wormy." In certain localities late varieties are sometimes badly injured by feeding punctures of the new generation of adults.

Apple.—Curculio injury to the apple has lately been the cause of considerable complaint. It is much like that done to the plum, though the young fruit is not so likely to fall to the ground when punctured, and the larvæ are probably never able to mature in fruit which remains on the tree. The young fruit may largely outgrow the egg puncture, which may show in the ripe fruit as a brown and roughened, more or less crescentic, spot which does not materially affect its value; but when badly punctured, especially by feeding of the beetles, the fruit as it grows becomes knotted and pitted. Fall and winter varieties may be seriously injured by the feeding upon the fruit of beetles of the new generation.

Peach.—On account of the thick fuzzy pubescence on the young peach, this fruit is perhaps attacked less early than is the plum, but the character of the injury is essentially the same. Many fall to the ground. Those remaining on the trees, if badly punctured, become knotty and misshapen and often exude masses of gum from the wounds. Such fruit will usually ripen prematurely. Ripe fruit which appears perfectly sound, but which contains nearly full-grown larvæ, is often found on the trees. To all appearances such fruit is in first-class condition and is thus often shipped to market.

Cherry.—In most cases infested cherries do not fall to the ground, the larvæ maturing in the fruit on the trees. Usually but a single larva is found in a fruit, and infestation is apt to go undetected.

Apricot and nectarine.—These are usually injured in much the same way as are plum and peach. Isolated trees loaded with apricots are often so badly infested that not a single fruit escapes.

Pear.—Curculio larvæ are apparently not able to develop in fruit on the trees, hence injury is confined to the egg and feeding punctures made by the adults when the pears are small. In fruit which does not fall the injury may be quite outgrown, but in cases of excessive puncturing the fruit is badly warped.

NATURAL ENEMIES.

Under the head of natural enemies are to be mentioned several parasites of the plum curculio which play a very important rôle in holding the insect in check. Perhaps the most important of these is a minute hymenopterous insect belonging to the family Mymaridæ, which attacks the egg, although the latter is apparently well protected under the skin of the fruit. This insect is known by the scientific name *Anaphes conotracheli* Girault. It is now known to occur in Georgia, North Carolina, Virginia, Maryland, the District of Columbia, Kentucky, Connecticut, Texas, and Indian Territory, and is apparently quite abundant. According to the few observations which have thus far been made, it destroys

in Maryland from 16 to 70 per cent of the eggs, and as the life cycle in June was only nine days, several generations of this parasite must successfully develop in the eggs of the plum curculio, thus increasing its efficiency.

The other parasites attack the larva or grub. They are *Sigalphus curculionis* Fitch and its variety *rufus* Riley, and *Thersilochus conotracheli* Riley. The former is of much more importance than the latter because of its greater abundance. It is a common parasite of several other coleopterous larvæ and is quite widely distributed. Limited observations indicate that this parasite destroys about 20 per cent of the larvæ of the plum curculio. *Thersilochus conotracheli* has not been



FIG. 4.—Jarring for the plum curculio in a Georgia peach orchard (original).

met with outside of New York State, and the influence it exerts in keeping down the curculio is perhaps very small.

Besides the true parasites several predaceous beetles and ants attack and destroy the curculio larvæ as they leave the fruit to enter the soil for pupation. Their value in most cases does not equal that of the parasites.

Chickens are said to help greatly in destroying the beetles, especially in small orchards planted near the home.

PREVENTIVE MEASURES.

Although many methods have been proposed for lessening the injury of this pernicious pest, only a few have proven of real value.

Jarring.—Among these, jarring is the method which is perhaps in

most general use in protecting plums and peaches, and by many orchardists it is believed to give the best results. Early observations upon the plum curculio showed that this insect has a habit of falling to the ground and "playing possum" when disturbed. A knowledge of this habit has led to the capture of the beetles on sheets held or spread beneath the trees, the trees being jarred by a sudden, forcible blow struck with a padded pole or mallet in order to dislodge the beetles.

In the spring, about the time the calyx or "shuck" is beginning to slip off from the newly set fruit, jarring is commenced and is continued daily or as often as the weather will permit for a period of four or five



FIG. 5.—The cart catcher in use in jarring for the plum curculio (after Slingerland).

weeks or until the operation ceases to yield many beetles. Jarring is best done in the early morning or late evening, for at these times the beetles are less active, drop more readily, and are not so likely to escape by flying or crawling from the sheets as they are at midday.

There are several kinds of catchers in common use by orchardists. One form is shown in figure 4 and consists of a light framework 12 feet long by 6 feet wide, over which a canvas is stretched. The jarring gang consists of five persons. Two of the frames of the dimensions given are used together, each frame being carried by a couple of women or boys, as shown in the figure. One frame is held on each side of the tree, while the fifth member of the gang, who carries a long-handled padded pole, gives the trunk of the tree a sharp forcible blow. With this outfit

a large number of trees may be jarred in a very short time. It is therefore especially suitable for work on a large scale. The curculios which fall to the sheets are collected and destroyed when the end of the row is reached, and the beneficial insects, principally ladybirds, are allowed to escape. Where jarring on a smaller scale is desired, sheets can be made of a size to be easily handled by one man. For this purpose frames 9 feet by $4\frac{1}{2}$ feet are convenient and will answer for moderately sized peach, plum, and cherry trees.

Another catcher which is in common use, especially by the plum growers of western New York (see figure 5), is a two-wheeled cart upon which is mounted a canvas covering arranged in the form of an inverted umbrella. There is a narrow opening at the front to receive the trunk of the tree. When the catcher is in position, the trunk of the tree is given a sharp blow. This causes the beetles to drop to the canvas, from which they are swept into the tin receptacle, or "hopper," hanging under the center of the cart directly beneath an opening in the canvas. Some operators place kerosene in the "hopper" to destroy the insects as soon as they fall into it. Others have chestnut roasters placed at the end of the rows, in which the insects and rubbish collected in the "hopper" are finally roasted.

Although the operations just described are somewhat laborious and expensive, many orchardists have demonstrated that the outlay in time and money thus invested will bring profitable returns. Some interesting figures concerning the cost of and results from this work as practiced in a Georgia orchard were obtained by Messrs. W. M. Scott and W. F. Fiske during the season of 1900 and published in Bulletin No. 31, new series, of this Bureau. Some 200,000 bearing peach and 50,000 bearing plum trees were jarred about 16 times during the period from April 18 to June 1. Eleven gangs, or 55 hands, with 5 attendants, were engaged in the work. The total cost for labor and repairs was placed at about \$1,000. The number of curculios caught during the season was estimated at about 137,000. On the assumption that one-half of these were females, each capable of laying 200 eggs, it will be seen that 13,700,000 eggs, less those deposited by the beetles before capture, were kept from the fruit. The amount of curculio damage in this orchard for the season was placed at about 4 per cent of the crop. In an adjacent orchard of 130,000 peach trees not jarred curculio injury was placed at 40 per cent of the crop.

Poisons.—It has long been known that the beetles feed on the plants upon which they lay their eggs, and numerous careful experiments have shown that they may be poisoned by thoroughly spraying the trees with arsenicals. The results of such work, however, appear to vary somewhat, depending on the relative abundance of the beetles during a given season. Many orchardists have adopted the practice of spraying for the curculio in preference to jarring, on account of the

labor involved in the latter and the frequency with which the work must be repeated to make it effective. Professor Crandall, in Illinois,¹ has shown that curculio injury to apples may be reduced some 20 to 40 per cent by a reasonable number of poison applications. The results of persistent spraying by orchardists in western New York are set forth by Professor Slingerland in Bulletin No. 235 of the Cornell Experiment Station. It is there stated that the growers are almost all in favor of spraying for the curculio, especially upon plums and cherries. The exact value of arsenicals in controlling the curculio on peach has apparently not yet been determined, though there are numerous growers who spray their peach trees every year and report good results. The foliage of peach is likely to be injured, however, by repeated applications of arsenical sprays, and the grower using these sprays for the first time should proceed with caution. In localities where it has been established that no injury results from their use, they are to be recommended. Other stone fruits, while liable to foliage injury from repeated applications of arsenicals, are apparently not so sensitive as is the peach, but care should be taken at all times that the poison be used as recommended below. Apple and pear are rarely, if ever, injured by the proper use of arsenicals. Of the poisons available—such as Paris green, “green arsenoid,” and arsenate of lead—the latter is least likely to be injurious and should be used where stone fruits are to be treated. Liability to injury from arsenical poisons will be greatly reduced by adding, to each 50 gallons of the spray, the milk of lime made by slaking 2 or 3 pounds of good stone lime. Where Bordeaux mixture is employed against scab and other fungous diseases, the arsenical may be used in the fungicide, and the milk of lime is then unnecessary. To be reasonably effective in killing the beetles, arsenate of lead should be used at the rate of 2 pounds to 50 gallons of water. Paris green or green arsenoid should not, on stone fruits, be used stronger than 1 pound to 150 or 200 gallons of water. On pome fruits a somewhat greater strength may be used without danger of injury to the foliage.

Since the period of feeding and egg laying of the curculio extends over several weeks from its emergence in spring, several applications of poison are necessary. The first application should be made as soon as the blossoms have fallen, and three or four subsequent applications should be made at intervals of eight to ten days. In the case of apple the usual two applications for the codling moth or canker-worms—just after petals fall and again within a week or ten days—will answer for the first two applications against the curculio. In spraying for the curculio too much stress can not be laid on the importance of making the applications as thorough as possible. The effort should be made to cover every leaf, twig, and fruit.

¹ Bul. 98, Ill. Agric. Exp. Sta., p. 553.

Cultivation.—Another vulnerable period in the life of the insect is that when the larva has reached its growth and has passed into the soil. At a distance varying from one-half to 2 inches from the surface the larva makes a small earthen cell in which to undergo its transformation to the pupa and, later, to the adult beetle. While these changes are taking place the insect is in a perfectly helpless condition, and the stirring of the soil with a cultivator at this period will doubtless break up the cells, causing the death of many of the delicate pupæ. Since cultivation is a necessary feature of orchard practice, effort should be made to carry on a part of it at a period when a majority of the insects are easily destroyed. Careful observations show that in the vicinity of Washington, D. C., and southward the larvæ begin to enter the soil about six weeks from the time fruit trees are in full bloom. In Illinois, according to Professor Crandall, about two months elapse between the period of full bloom and the date at which larvæ begin to enter the soil. Since the period of maximum egg laying covers from four to five weeks, there is a like period when the pupæ are in the soil in maximum numbers. Cultivations to destroy the curculio should therefore begin six or eight weeks, according to latitude, from the time of full bloom of the trees and should be continued for four or five weeks. Such work could readily be arranged for as part of the regular cultivation given the orchard.

Gathering fallen fruit.—The number of curculios can be greatly reduced by picking up and destroying the fallen fruit infested with larvæ. Much of the infested fruit falls to the ground several days before the larva is full grown and ready to leave it. If this be gathered and burned, at intervals of three or four days, it will result in greatly lessening the number of beetles to attack the fruit in the fall and following spring.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *April 14, 1906.*

CIRCULAR NO. 74.

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE PERIODICAL CICADA IN 1906.

(*Tibicen septendecim* L.)

By C. L. MARLATT,

Entomologist and Acting Chief in Absence of Chief.

Two broods of the periodical cicada will reappear this year, one an important and widely distributed seventeen-year brood and the other an unimportant, small, and scattering thirteen-year brood.

SEVENTEEN-YEAR BROOD XIV.

The localities where this brood may be expected are indicated on the map (fig. 2) on page 3. This brood has a peculiar interest, inasmuch as it is the one which was first noted, or recorded in literature at least, by the early European colonists on this continent. The earliest mention of this peculiar insect is that given in the work entitled "New England's Memorial," by Nathaniel Moreton, printed at Cambridge, Mass., in 1669.

The following transcription of this account, reproduced from Bulletin

No. 14, new series, of this Bureau, is taken from an editorial note to an article on the "Locust of North America" in the Barton Medical and Physical Journal of 1804 (Vol. I, pp. 52-59). Referring to Moreton, the editor says:

Speaking of a sickness which, in 1633, carried off many of the whites and Indians, in and near to Plimouth [Plymouth], in Massachusetts, he says, "It is to be observed, that the Spring before this Sickness, there was a numerous company of *Flies*, which, were like for bigness unto *Wasps* or *Bumble-Bees*, they came out of little holes in the ground, and did eat up the green things, and made such a constant yelling noise as made all the woods ring of them, and ready to deaf the hearers; they were not any of them heard or seen by the *English* in

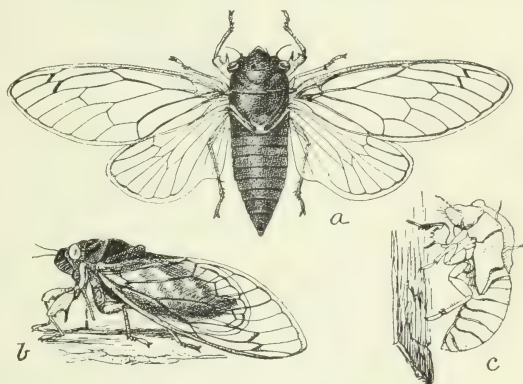


FIG. 1.—The periodical cicada (*Tibicen septendecim*): a, adult; b, same, side view; c, shed pupal skin. Natural size (original).

the Country before this time: But the *Indians* told them that sickness would follow, and so it did, very hot in the months of *June, July and August* of that Summer," viz. 1633. He says, "Toward Winter the sickness ceased;" and that it was "a kinde of a pestilent Feaver."—New England's Memoriall, &c., pp. 90 and 91.

The fact noted, that the native Indians associated the recurrences of this insect with pestilential diseases, is interesting as showing that the cicada had probably long been under observation by them and had exerted a vivid influence on their imaginations.

Doctor Riley, referring to this record in his account of the periodical cicada, written in 1868, indicates that the year here mentioned is probably an erroneous record, as shown by the subsequent reappearances in the same locality; in other words, the date assigned was doubtless 1634 instead of 1633. The first publication of this record thirty-five years after its occurrence would give ample leeway for an error of this nature. There is, of course, the possibility that the occurrence recorded by Moreton was a premature one, but a mistake of one year in the date is a more reasonable explanation. The subsequent recurrences of this brood for the years 1651, 1668, 1685, 1702, 1719, 1736, 1753, and 1770 appear not to have been recorded; but the later ones, namely, for 1787, 1804, 1821, 1838, 1855, 1872, and 1889 have been definitely reported. Our knowledge of the extent of this brood, up to 1889, is practically based upon Doctor Fitch's observations in 1885 in the account of his third brood, since its reappearance in 1872 did not, apparently, attract any attention. Doctor Fitch, however, confused this seventeen-year brood with the great *tredecim* brood which occurred in 1855, the year of his record, and the exact dividing line between the two broods is still open to question. In asking for reports on the occurrence of this brood in 1889 Riley and Howard gave its extent as follows:

The region commences in southeastern Massachusetts, extends south across Long Island and along the Atlantic coast of New Jersey, Delaware, and Maryland as far as Chesapeake Bay; then up the Susquehanna River in Pennsylvania to a point a little below Harrisburg; thence westward in Ohio, embracing the southwestern corner of the State and the northwestern portion of Kentucky, and then upward through southwestern Indiana, ending in central Illinois. It is possible also that there is an eastward extension of the region from Kentucky into southern West Virginia, as cicadas occurred in 1855 in the Kanawha Valley, and also in the counties of Buncombe and McDowell, in North Carolina; but as these appearances were not verified in 1872, it is probable that they belonged to Brood XVIII, which is of the thirteen-year race.

The distribution of this brood, as given below, is reproduced from Bulletin No. 14, referred to above, and is based on the records given by Riley and Howard, with such additions and corrections as were gained from the records of 1889, Prof. J. B. Smith adding some records from New Jersey, Dr. William A. Buckout defining its limits in Pennsylvania, and Mr. E. A. Schwarz and others adding various localities.

The distribution, by States and counties, is as follows:

District of Columbia.—Throughout.

Georgia.—Gordon, Habersham, Rabun, Towns, Union, White.

Illinois.—Boone, Jo Daviess, Lake, McHenry, McLean, Putnam, Stephenson, Winnebago.

Indiana.—Clay, Crawford, Daviess, Gibson, Greene, Knox, Lake, Lawrence, Pike, Posey, Sullivan, Vanderburg, Vigo, Warrick.

Kentucky.—Adair, Allen, Bath, Bourbon, Boyd, Breckinridge, Carter, Casey, Clark, Clinton, Cumberland, Estill, Fayette, Fleming, Franklin, Greenup, Jackson, Jefferson, Laurel, Lewis, McLean, Madison, Mason, Metcalfe, Montgomery, Owsley, Powell, Pulaski, Rockcastle, Russell, Shelby, Trimble, Wayne.

Maryland.—Washington.

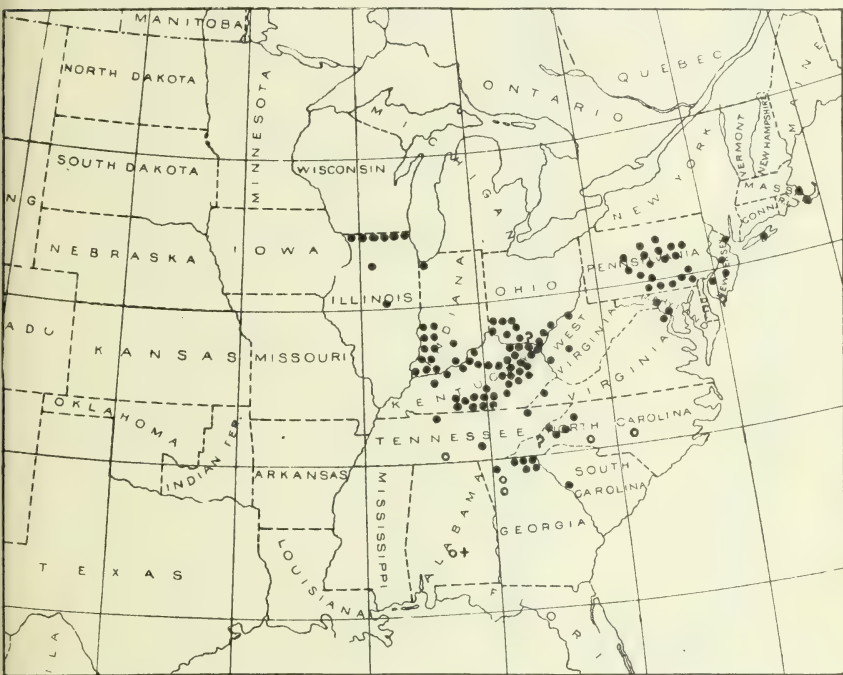


FIG. 2.—Map showing distribution of Broods XIV and XVIII, 1906. The black disks are the records of the Seventeen-year Brood XIV (Riley VIII), and the circles in the States of Alabama, Georgia, Tennessee, and North Carolina are of the small Thirteen-year Brood XVIII (Riley XVI).

Massachusetts.—Barnstable, Plymouth.

New Jersey.—Bergen, Burlington, Cape May, Gloucester, Mercer.

New York.—On Long Island.

North Carolina.—Buncombe, Caldwell, Haywood(?), McDowell, Madison.

Ohio.—Adams, Brown, Butler, Clinton, Gallia, Hamilton, Highland, Lawrence, Meigs, Scioto(?), Warren.

Pennsylvania.—Adams, Berks, Blair, Center, Chester, Clearfield, Clinton, Columbia, Cumberland, Franklin, Huntingdon, Lancaster, Lycoming, Mifflin, Montour, Northumberland, Snyder, Union, York.

South Carolina.—Edgefield.

Tennessee.—Bledsoe, Claiborne, Robertson.

Virginia.—Alexandria, Wise.

West Virginia.—Kanawha, Logan, Wood.

It is very desirable to have the records for this brood confirmed with its occurrence this year, and accompanying this circular, therefore, a reply card is sent on which any information relating to this brood may be recorded as indicated on the card. *A negative record is often quite as valuable as one of actual occurrence.* Inasmuch as the periodical cicada does not appear, as a rule, until about the last week of May, it

is well not to fill out the cards or return them before the middle of June. Later than the middle of June there is danger of confusion with the annual species of cicada, which will then begin to appear.

THIRTEEN-YEAR BROOD XVIII.

A very scattering brood of the thirteen-year race of the periodical cicada appears this year in conjunction with the much larger and more widely distributed seventeen-year brood. This thirteen-year brood is based on the testimony of Dr. G. B. Smith, who gives a record of its occurrence in Cherokee County, Ga., in 1828, 1841, and 1854. Dr. J. G. Morris recorded its appearance in the same locality also in 1867. This is Doctor Riley's Brood XVI, and some additional records were added by him, so that it is now known in four States, occurring, however, in scattered localities. The localities for this brood as listed by Doctor Riley are given below. None of them were verified in 1893, but an additional and very doubtful locality—Montgomery County, Ala.—was reported.

It is very desirable to have confirmation of all the localities mentioned for this brood, and persons receiving this circular throughout the region rep-

resented will confer a great favor by reporting any occurrences which may come to their notice. Any periodical cicadas appearing in the higher elevations in the mountain regions of the States referred to will probably be of the seventeen-year race, but emergences at low levels

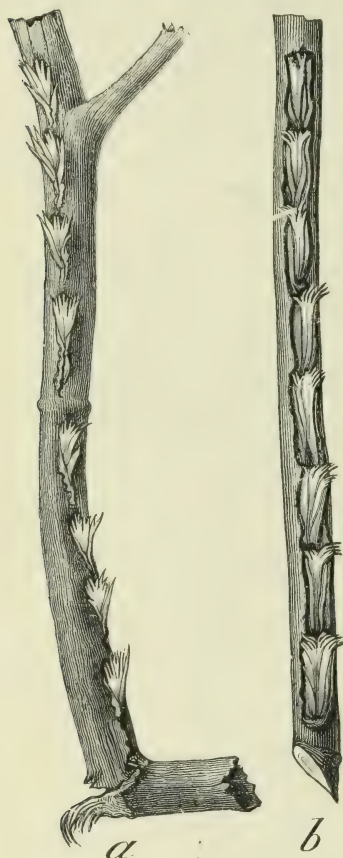


FIG. 3.—Egg punctures of the periodical cicada: *a*, twig showing recent punctures, from front and side, and illustrating manner of breaking; *b*, twig showing older punctures, with retraction of bark and more fully displaying the arrangement of fibers. Natural size (after Riley).

will very likely belong to the thirteen-year brood. The distribution, by States and counties, is as follows:

Alabama.—Lowndes, Montgomery (?).

Georgia.—Cherokee, Cobb.

North Carolina.—Lincoln, Moore.

Tennessee.—Lincoln.

GENERAL CONSIDERATIONS.

The periodical cicada is so well known that a general account of it in this place is unnecessary. The illustration (fig. 1) will recall it to anyone who has ever observed it. When it appears in great numbers it naturally causes considerable alarm and arouses fears for the safety of shade trees and orchards. The actual damage, however, is usually slight, except in the case of newly planted orchards, and even here, by rigorous pruning back after the cicada has disappeared, much of the injury caused by the egg punctures (fig. 3) can be obviated. As a matter of precaution, however, it might be well not to locate new orchards this spring in recently cleared ground or in proximity to woods in any of the regions where the cicada is here recorded. In many cases, however, the clearing up and cultivation of the ground will have destroyed the larvæ of the cicada, and it may not appear.

The exact date of emergence of the adult cicadas from the ground will vary somewhat with the season. The experience of many years, however, indicates that most of the individuals will come out during the last week in May. Very frequently the holes through which the cicadas will emerge will appear in the soil some weeks before the insects actually come out. These holes are a little larger around than a lead pencil and are frequently so numerous as absolutely to cover the surface of the ground.

If there be any doubt as to the identity of the cicada, especially from records made about or at the middle of June, it would be well to send specimens for identification along with the record. It is hoped that everyone who receives this circular will keep a sharp lookout for swarms of this brood of cicada and assist the Bureau in fixing its range accurately by sending prompt and explicit information. Bulletin No. 14, new series, of this Bureau will be mailed to anyone desiring further information on the periodical cicada.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., April 16, 1906.

(Compiled and revised to July 1, 1909.)

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

REQUIREMENTS TO BE COMPLIED WITH BY NURSERYMEN OR OTHERS WHO MAKE INTERSTATE SHIPMENTS OF NURSERY STOCK.

By A. F. BURGESS,

Expert in Charge of Breeding Experiments.

For the information of nurserymen or others who desire to ship nursery stock to points outside the States in which their nurseries are located, a brief statement of the requirements is given herewith. Changes are continually being made on account of the enactment of new laws or the amendment of old ones, and modifications of the regulations of different States are made from time to time by the authorities in charge of the enforcement of the laws. On this account Circular No. 75 has been revised and the requirements given are in force on the date of its publication. For the convenience of nurserymen who may wish to write to the officials in charge of inspection work the names and addresses of the latter are given.

Alabama.—Persons shipping stock into the State must file a duplicate certificate of inspection and obtain official tags. The latter must be placed upon every package of stock delivered in the State. Tags are furnished at cost, as follows: One hundred, 65 cents; 200, \$1; 500, \$1.60, post paid. One thousand may be obtained for \$2.20 by express collect. Prof. R. S. Mackintosh, Auburn, Ala. (Act of 1903.)

Arizona.—Any person, firm, or corporation shipping stock into the Territory of Arizona must within twenty-four hours after its arrival notify the quarantine inspector of the district in which the stock is received, and hold the same for immediate inspection. All stock shipped into the Territory must be labeled with a certificate of inspection, and shipments not so labeled will be immediately destroyed or sent out of the Territory at the option of the owner, and at his expense. Any shipment of nursery stock, buds, fruit pits, or fruits brought into the Territory which shall be found infested will be

immediately destroyed or sent out of the Territory at the option of the owner. Prof. R. H. Forbes, Secretary, Arizona Horticultural Commission, Tucson, Ariz. (Act of 1909.)

Arkansas.—Shipments must bear a certificate of inspection. Mr. C. F. Adams, State Inspector, Fayetteville, Ark. (Act of 1903.)

California.—Shipments of stock sent into the State are subject to inspection and must bear the name of the consignor and consignee and a statement of where the stock was grown. The Commissioner has also issued a quarantine order making it unlawful to ship into the State any trees or plants from Florida, Louisiana, or other States known to contain infestations of the *Aleyrodes citri* (white fly). There is also a quarantine order requiring all cotton seed sent into the State to be consigned to a county horticultural commissioner and by him fumigated before delivery to the consignee. Notice of shipments should be sent to Hon. J. W. Jeffrey, Commissioner of Horticulture, Sacramento, Cal.

Colorado.—Shipments into the State are inspected by county inspectors. (Amended act of 1907.)

Connecticut.—Shipments of stock into the State must bear certificates of inspection, issued by a State or Government officer, and a statement by the owner that they have been thoroughly fumigated. Dr. W. E. Britton, State Entomologist, New Haven, Conn. (Amended act of 1903.)

Delaware.—Shipments into the State must be accompanied by a certificate of inspection of a State or Government official, and the owner or shipper must certify that the stock has been fumigated. Delaware nurserymen are required to fumigate their stock. Mr. Wesley Webb, Dover, Del. (Amended act of 1901.)

Florida.—It is unlawful for any nonresident person or persons, corporation or firm, to sell or offer for sale nursery stock in the State of Florida without having first paid a license tax of \$25 annually to the collector of revenues of the county in which the stock is sold or offered for sale. (This law is interpreted as applying to peddlers only, and not intended to interfere with shipments into the State.) Upon payment of this amount a license will be issued by the county judge. (Act of 1905.) It is unlawful for any person to knowingly sell or give away diseased nursery stock or seeds in the State of Florida. Dr. E. W. Berger, Entomologist, Florida Agricultural Experiment Station, Gainesville, Fla. (Act of 1906.)

Georgia.—Shipments into the State must be accompanied with certificates of inspection and copies of the official tags of the State Board of Entomology. These may be obtained by submitting a duplicate of the official certificate of inspection and a statement that all stock shipped into the State will be properly fumigated. Tags are fur-

nished at cost. Mr. E. L. Worsham, State Entomologist, Atlanta, Ga. (Act of 1900.)

Hawaii.—Shipments are subject to the regulations of the Board of Commissioners of Agriculture and Forestry, and are subject to inspection and quarantine at Honolulu or Hilo, which are the only ports where they are allowed to be landed. For inspection lists and special information address Hon. Marston Campbell, President, Honolulu, Hawaii.

Idaho.—Persons desiring to sell or ship stock into this State must file a bond in the sum of \$1,000 with the State Board of Horticulture, conditioned on a faithful compliance with the requirements of the law, and secure a permit to do business in the State. Shipments must bear official certificates of fumigation, and the name of the grower and consignee must appear on the package. Mr. J. R. Field, State Horticultural Inspector, Boise, Idaho.

Illinois.—Shipments into the State must be accompanied with certificates of inspection. The State Entomologist is required by law to furnish annually to Illinois nurserymen a list of State and Government inspectors whose certificates may be received as equally valid with his own, and the nurserymen receiving stock under such certificates are authorized to substitute the Illinois certificate of inspection. Agents and dealers must file sworn statements with copies of certificates showing the source from which their stock is obtained, for the approval of the State Entomologist. Dr. S. A. Forbes, State Entomologist, Urbana, Ill. (Act of 1907.)

Indiana.—Stock shipped into the State must be accompanied by certificates of inspection signed by a State or Government inspector. Each shipment must bear the name of the consignor and the consignee. Uncertified shipments must be reported by the railroad company receiving the same. Mr. Benjamin W. Douglass, State Entomologist, Indianapolis, Ind. (Act of 1909.)

Iowa.—Shipments into the State must be accompanied by official certificates of inspection, copies of which should be previously filed for approval with the State Entomologist. Prof. H. E. Summers, State Entomologist, Ames, Iowa. (Amended act of 1906.)

Kansas.—Stock shipped into the State must be accompanied by certificates of inspection. Prof. S. J. Hunter, State Entomologist, Lawrence, Kans., has charge of the inspection in the southern section of the State; Prof. T. J. Headlee, State Entomologist, Manhattan, Kans., has charge of the inspection in the northern section of the State. (Act of 1907.)

Kentucky.—Shipments into the State must be accompanied with official certificates of inspection, copies of which should be filed with
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the State Entomologist. Prof. H. Garman, State Entomologist, Lexington, Ky. (Act of 1897.)

Louisiana.—Shipments sent into the State must be accompanied with official certificates of inspection. When a shipment containing two or more orders is sent to an agent or dealer for delivery to different persons, a certificate must accompany each individual order. Mr. Wilmon Newell, Entomologist, State Crop Pest Commission, Baton Rouge, La. (Act of 1903, Regulations of State Crop Pest Commission, approved April 11, 1907.)

Maine.—All stock shipped into the State must be accompanied with official certificates of inspection, but the State Entomologist is empowered by law to inspect at the point of destination any stock which may be received; and should such stock be found infested with injurious insects or infected by plant diseases he may destroy the same or return it to the consignor. Mr. E. F. Hitchings, State Entomologist, Augusta, Me. (Amended act of 1909.)

Maryland.—Stock sent into the State must bear the name of the consignor and consignee and a certificate of inspection. Duplicate certificates should be filed with the State Entomologist. Prof. T. B. Symons, State Entomologist; Prof. J. B. S. Norton, State Pathologist, College Park, Md. (Act of 1898.)

Massachusetts.—Any person, firm, or corporation desiring to ship stock into the State must file a copy of his or its official certificate of inspection with the State Nursery Inspector, and if the certificate is satisfactory official tags bearing the certificate and seal of the State will be issued at cost. Any shipment or package of stock shipped into the State without such official tag is liable to confiscation. The State Nursery Inspector has authority to inspect at the point of destination all stock coming into the State, and if it is found infested with injurious pests he may cause it to be destroyed or returned at the expense of the owner. Agents selling stock in the State must secure a license from the State Nursery Inspector. Dr. H. T. Fernald, State Nursery Inspector, Amherst, Mass. (Act of 1909.)

Michigan.—Nurserymen selling stock in this State must pay a license fee of \$5 and furnish a bond of \$1,000, with satisfactory sureties. Shipments must be accompanied with certificates of inspection and, if of species subject to the attack of the San Jose scale, certificates by the nurserymen that the stock has been properly fumigated. Prof. L. R. Taft, State Inspector of Orchards and Nurseries, Agricultural College, Mich. (Amended act of 1905.)

Minnesota.—Stock shipped into the State must bear a certificate of inspection. Prof. F. L. Washburn, State Entomologist, St. Anthony Park, Minn. (Act of 1903.)

Mississippi.—Before shipping stock into the State a copy of an official certificate of inspection must be filed with the Entomologist of the Experiment Station, which must state that in addition to the regular inspection the stock has been fumigated under the direction of the official issuing the certificate. Failure to comply with this requirement renders the stock liable to confiscation and destruction. All shipments must be accompanied with such a certificate. Mr. R. W. Harned, Experiment Station, Agricultural College, Miss. (Act of 1908.)

Missouri.—Stock shipped into the State must bear the name of the consignor and the consignee, a statement of the contents, and an official certificate of inspection. In the absence of the State Entomologist, applications for certificates of inspection should be made to Mr. E. P. Taylor, Missouri State Fruit Experiment Station, Mountain Grove, Mo.

Montana.—All stock brought into the State must be unpacked, inspected, and, if necessary, fumigated at one of the designated quarantine stations, viz, Miles City, Billings, Dillon, Missoula, Kalispell, Great Falls, Troy, Plains, Glasgow, or Thompson Falls. Nursery stock may be inspected and, if necessary, fumigated at other points of delivery on payment of all cost. In order to sell or deliver nursery stock it is necessary first to obtain a license by paying a fee of \$25 and by filing with the Secretary of the State Board of Horticulture a bond in the sum of \$1,000 annually. Notice of shipment, including an invoice of stock, must be sent to Mr. Joseph W. Wallisch, Secretary, Montana State Board of Horticulture, Harbour Block, Butte, Mont. (Act of 1899.)

Nebraska.—No nursery-inspection law. Local nurseries inspected and certificates issued by Prof. Lawrence Bruner, Acting State Entomologist, Lincoln, Nebr.

Nevada.—No nursery-inspection law.

New Hampshire.—Stock shipped into the State must bear a certificate of inspection or a statement containing an affidavit that it has been properly fumigated. Prof. E. D. Sanderson, State Nursery Inspector, Durham, N. H. (Act of 1903.)

New Jersey.—Stock shipped into the State must be accompanied with a certificate of inspection and a statement from the shipper that it is a part of the stock inspected and whether it has been fumigated with hydrocyanic-acid gas. Dr. John B. Smith, State Entomologist, New Brunswick, N. J. (Act of 1903.)

New Mexico.—No law relating to nursery inspection.

New York.—All transportation companies are required by law to notify the Commissioner of Agriculture of the receipt of nursery stock consigned to points within the State, and stock can not be un-

packed until a permit has been secured from the Commissioner of Agriculture. All custom-house brokers doing business in the State of New York are required to file a list containing names and addresses of all persons, firms, or corporations with whom they are engaged or intend to engage in the sale or delivery of nursery stock; they are also required to notify the Commissioner of Agriculture on receipt of consignments and give all points to which stock is being shipped. Hon. R. A. Pierson, Commissioner of Agriculture, Albany, N. Y. (Amended act of 1909.)

North Carolina.—Shipments sent into this State must bear official certificates of inspection and should be fumigated and a statement to that effect signed and attached by the consignor. Duplicate certificates must be filed with the State Entomologist. Prof. Franklin Sherman, jr., State Entomologist, Raleigh, N. C. (Act of 1897.)

North Dakota.—No nursery-inspection law.

Ohio.—Shipments must be accompanied with official certificates of inspection or fumigation. Agents and dealers must file sworn statements as to sources from which their stock is obtained. Mr. N. E. Shaw, Chief Inspector, Department of Agriculture, Columbus, Ohio.

Oklahoma.—The owners or operators of nurseries who desire to ship stock into the State of Oklahoma are required to make an application for a permit. This will be issued by the Board of Agriculture upon the filing of a certificate of inspection or the report of inspection from the State inspector who examined the stock, and in addition the application must be accompanied by a remittance of \$5. If satisfactory, the board will issue a permit over the signature of its secretary, and in addition to the above may require further evidence of integrity to establish the responsibility and good faith of the applicant. All shipments must be accompanied by a tag on which is printed a copy of this permit over the facsimile signature of the secretary of the board. All agents canvassing for nurseries located outside the State are required to carry a duplicate of the permit of their principals, which duplicate is issued upon payment of \$1. Quotations on tags will be forwarded upon application to the secretary. Address all communications to Oklahoma State Board of Agriculture, Mr. C. F. Barrett, Secretary, Guthrie, Okla. (Act of 1905.)

Oregon.—Stock is subject to inspection on arrival at quarantine stations. Mr. H. W. Williamson, Secretary State Board of Horticulture, Portland, Oreg. (Amended act of 1905.)

Pennsylvania.—Shipments of nursery stock into the State must be plainly labeled on the outside with the names of the consignor and consignee, and a certificate showing that the contents have been inspected and that the stock (excepting conifers and herbaceous plants) therein contained have been properly fumigated. Dealers in nursery

stock are furnished certificates under certain restrictions. Transportation companies are required to reject all stock entering the State unless certificates of inspection and fumigation are attached. Prof. I. A. Surface, Economic Zoologist; Mr. E. B. Engle, Inspector, Harrisburg, Pa. (Act of 1905.)

Porto Rico.—Nursery stock will be received only through three ports of entry, namely, San Juan, Ponce, and Mayaguez, and must be accompanied with an official certificate of inspection. It is subject to inspection by local inspectors on arrival at said ports of entry. Inspectors are appointed by the Governor. (Act of 1905.)

Rhode Island.—Shipments must be accompanied with certificates of inspection or affidavits of fumigation. Mr. A. E. Stene, State Nursery Inspector, Kingston, R. I. (Act of 1904.)

South Carolina.—A duplicate certificate of inspection must be filed with the State Entomologist and an official tag of the State Board of Entomology secured by nurserymen desiring to ship stock into the State. This tag and an official certificate of fumigation must be attached to all shipments. Prof. W. A. Thomas, State Entomologist, Clemson College, S. C. (Act of 1905.)

South Dakota.—All nursery stock shipped into the State must be accompanied with a certificate of inspection issued by the State Entomologist from the State from which it was shipped. Any person, firm, or corporation owning a nursery which sells stock to be delivered in this State must certify where the stock was grown, and attach this statement to all shipments. Prof. Robert Matheson, State Entomologist, Brookings, S. Dak. (Act of 1909.)

Tennessee.—A certificate of inspection signed in person by the inspector or the State Entomologist must be filed in the office of the Tennessee State Board of Entomology, Knoxville, Tenn., previous to all shipments. All nursery stock must be fumigated and a tag indicating the same placed upon each shipment. Prof. H. A. Morgan, State Entomologist, Knoxville, Tenn. (Act of 1905.)

Texas.—Any nurseryman desiring to ship stock into the State must file with the Commissioner of Agriculture a certified copy of his certificate of inspection, which must show that the stock to be shipped has been examined by a State or local inspector and that it is free from all dangerous insect pests or contagious diseases. If fumigation is required in the State from which the stock is shipped, it must be thoroughly fumigated before shipment. On receipt of the certificate above mentioned the Commissioner of Agriculture is required to make an investigation as to the moral standing and integrity of the applicant, and if this is satisfactory the Commissioner of Agriculture will, on receipt of a fee of \$5, issue to the applicant a certificate permitting stock to be shipped into the State. Each box,

bale, or package of stock must bear a tag on which is a printed copy of the certificate of the Entomologist who examines the stock and the certificate of the Commissioner of Agriculture of Texas. Hon. Ed. R. Kone, Commissioner of Agriculture, Austin, Tex. (Act of 1909.)

Utah.—All nursery stock shipped into the State will be inspected on arrival and disinfected if such treatment is deemed necessary. Trees affected with crown gall or hairy-root disease will be destroyed by burning. Nurserymen doing business in the State must pay an annual license fee of \$2.50 and file a bond in the sum of \$500. The inspection work is in charge of the State Horticultural Commission, Mr. J. Edward Taylor, State Inspector, Salt Lake City, Utah.

Vermont.—Stock shipped into the State must be accompanied with a certificate of inspection. Prof. Wm. Stuart, State Nursery Inspector, Burlington, Vt.

Virginia.—Duplicate certificates of inspection must be filed by nurserymen shipping stock into the State and official tags obtained from the Board of Crop Pest Commissioners; also a registration fee of \$20 must be paid. Tags furnished at cost. Mr. J. L. Phillips, State Entomologist, Blacksburg, Va. (Amended act of 1903.)

Washington.—Before soliciting or engaging in selling nursery stock in this State a bond of \$1,000 and a license fee of \$5 must be paid by nurserymen and a license fee of \$2.50 by agents and dealers. Notice must be sent previous to the shipment of stock, giving the names of the nurserymen and the places at which it is to be delivered. Hon. F. A. Huntley, Commissioner of Horticulture, Tacoma, Wash. (Act of 1907.)

West Virginia.—All stock shipments into the State must be accompanied by an official certificate of inspection and fumigation. Notice of shipments must be sent ten days before the time of delivery, to the Director of the West Virginia Experiment Station, stating the number of trees in each consignment, the place from which such are to be shipped, and their destination. Agents and dealers who sell stock must secure a license from the assessor in the county where the stock is sold and pay a fee of \$10 to the sheriff of the county. Prof. J. H. Stewart, Director Agricultural Experiment Station, Morgantown, W. Va. (Amended acts of 1905 and 1907.)

Wisconsin.—Any person, firm, or corporation selling or shipping stock into the State must secure a license, which will be granted after a copy of their official certificate of inspection has been filed and a fee of \$10 paid by the applicant. Agents must carry a duplicate copy of the licenses held by their principals. Duplicates are furnished at a cost of \$1 each. Parties doing mail-order business are required to secure licenses. Stock received from foreign countries must be held by the owner unopened until it has been examined and released

by the inspector. All persons or companies engaged in selling or shipping fruit trees into the State are required to obtain official tags which will be issued by the State inspector at a cost not exceeding 30 cents per thousand. Mr. A. J. Rogers, jr., State Orchard and Nursery Inspector, Madison, Wis. (Act of 1909.)

Wyoming.—Any person or firm wishing to do business in the State must first obtain a license. Licenses are issued on application for a period terminating on July 1 of the next succeeding inspection year (approximately two years). All applications must be accompanied by the license fee (\$25), a bond in the sum of \$500 conditioned that the principal will faithfully obey the law of the State of Wyoming, and by a certified certificate of inspection from an authorized inspector in the State from which shipments are to be made. On receipt of these, the Secretary of the State Board issues authorized shipping tags (at cost). Nursery stock may not enter the State and transportation companies may not deliver unless such tags be attached to each and every box, bundle, or bale. For circular of detailed information address Prof. Aven Nelson, Secretary State Board of Horticulture, Laramie, Wyo. (Act of 1905.)

Canada.—Shipments of stock into Canada are unpacked and fumigated by Government inspectors and must arrive within the time specified at the following ports of entry: St. Johns, Quebec; Niagara Falls, Ontario, and Windsor, Ontario, from March 15 to May 15 and from September 26 to December 7; St. John, New Brunswick, and Winnipeg, Manitoba, from March 15 to May 15 and from October 7 to December 7; Vancouver, British Columbia, from October 1 to May 1. Mr. Arthur Gibson, Acting Entomologist, Ottawa, Ontario.

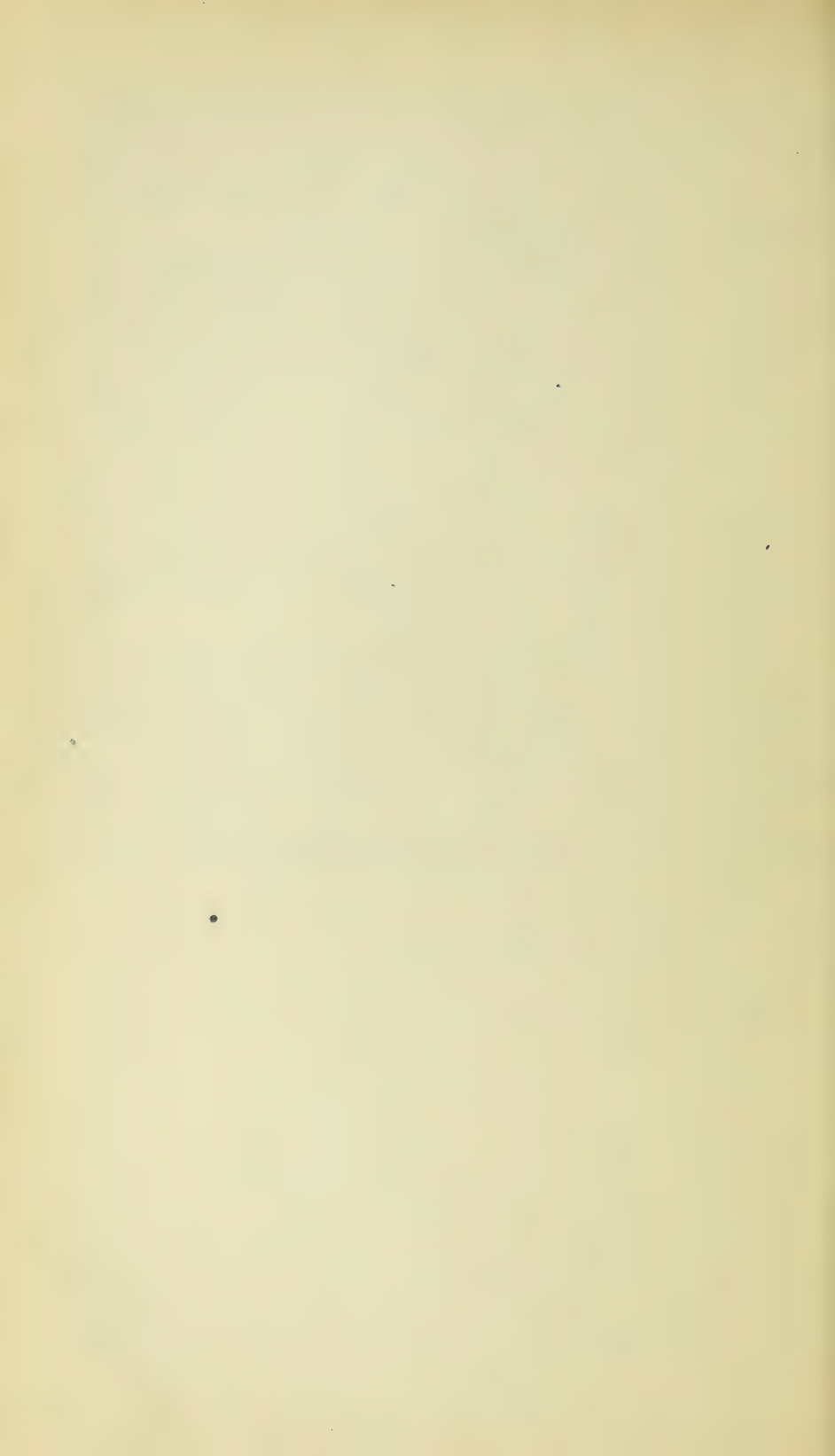
Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *June 9, 1908.*

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United States Department of Agriculture,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

LIST OF PUBLICATIONS OF THE BUREAU OF ENTOMOLOGY.

Compiled by MABEL COLCORD, *Librarian*.

There has been a demand from librarians, members of this Bureau, and others interested in entomology for a complete list of the publications of the Bureau and of those of the Department of Agriculture in general bearing on the subject and published by members of the Bureau or under its auspices. To supply this demand the following list has been compiled.

Applications for the priced publications mentioned in this list should be addressed to the Superintendent of Documents, Government Printing Office, Washington, D. C. All remittances should be made payable to him and not to the Department of Agriculture, and should be sent by postal money order or New York exchange. Currency may be sent at sender's risk, but postage stamps, foreign money, and uncertified checks will not be accepted.

The Farmers' Bulletins, circulars, separates, and popular summaries are sent free, on application to the Secretary of Agriculture; but applications from residents of foreign countries, to whom the price of these is 6 cents each, including postage, should be made to the Superintendent of Documents, Government Printing Office, Washington, D. C. No charge is made for postage on documents forwarded to points in the United States, Guam, Hawaii, Philippine Islands, or Porto Rico, nor to Canada, Cuba, or Mexico. To other countries the regular rate of postage is charged, and remittances must cover such postage.

Where scientific names of species are given in brackets these do not occur in the titles of the publications, but are inserted for the convenience of those not familiar with the common names.

ANNUAL REPORTS.

[The Division of Entomology was established in 1863 by the appointment of Townsend Glover as Entomologist. The annual reports of the Entomologist are bound with those of the Secretary of Agriculture, and for some years have also been issued in independent form, known as author's editions.]

Previous to the establishment of the division, articles of entomological interest appeared in the agricultural reports of the Patent Office. These articles are indexed in "The General Index of the Agricultural Reports of the Patent Office for 1837-1861, and of the Department of Agriculture for 1862-1876." *a*]

Report of the Entomologist for 1863. By Townsend Glover. (In Annual Report Commissioner of Agriculture for 1863. pp. 561-579.) Price 60 cents. Postage 21 cents.

Report of the Entomologist for 1864. By Townsend Glover. (In Annual Report Commissioner of Agriculture for 1864. pp. 540-564.) Price 60 cents. Postage 19 cents.

Report of the Entomologist for 1865. By Townsend Glover. (In Annual Report Commissioner of Agriculture for 1865. pp. 33-45.) Price 60 cents. Postage 19 cents.

Report of the Entomologist for 1866. By Townsend Glover. (In Annual Report Commissioner of Agriculture for 1866. pp. 27-45.) Price 60 cents. Postage 19 cents.

Report of the Entomologist for 1867. By Townsend Glover. (In Annual Report Commissioner of Agriculture for 1867. pp. 58-76, figs. [16].) Price 60 cents. Postage 15 cents.

[Report of the Entomologist for 1868.] By Townsend Glover. Title: The food and habits of beetles. (In Annual Report Commissioner of Agriculture for 1868. pp. 78-117, figs. [120].) Price 60 cents. Postage 17 cents.

Report of the Entomologist for 1869. By Townsend Glover. (In Annual Report Commissioner of Agriculture for 1869. pp. 60-64.) Price 70 cents. Postage 19 cents.

Report of the Entomologist and Curator of the Museum for 1870. By Townsend Glover. (In Annual Report Commissioner of Agriculture for 1870. pp. 65-91, figs. 60.) Price 65 cents. Postage 18 cents.

Report of the Entomologist and Curator of the Museum for 1871. By Townsend Glover. (In Annual Report Commissioner of Agriculture for 1871. pp. 69-88, figs. 23.) Price 55 cents. Postage 14 cents.

Report of the Entomologist and Curator of the Museum for 1872. By Townsend Glover. (In Annual Report Commissioner of Agriculture for 1872. pp. 112-138, figs. 26.) Out of print.

Report of the Entomologist and Curator of the Museum for 1873. By Townsend Glover. (In Annual Report Commissioner of Agriculture for 1873. pp. 152-169, figs. 10.) Price 40 cents. Postage 13 cents.

Report of the Entomologist and Curator of the Museum for 1874. By Townsend Glover. (In Annual Report Commissioner of Agriculture for 1874. pp. 122-146, figs. 20.) Out of print.

Report of the Entomologist for 1875. By Townsend Glover. (In Annual Report Commissioner of Agriculture for 1875. pp. 114-140, figs. 63.) Price 60 cents. Postage 17 cents.

a By the Commissioner of Agriculture. Washington: Government Printing Office. 1876. (Now out of print.)

- Report of the Entomologist and Curator of the Museum for 1876. By Townend Glover. (In Annual Report Commissioner of Agriculture for 1876. pp. 17-46, figs. 59.) Price 40 cents. Postage 14 cents.
- Report of the Entomologist and Curator of the Museum for 1877. By Townend Glover. (In Annual Report Commissioner of Agriculture for 1877. pp. 89-148, pls. 5.) Price 70 cents. Postage 18 cents.
- Report of the Entomologist, Charles V. Riley, August 22, 1879. pp. 52+[1], pls. 7. 1879. (Author's edition from the Annual Report of the Commissioner of Agriculture for the year 1878. pp. 207-257, pls. 7.) Out of print. Report of Commissioner for 1878. Price 70 cents. Postage 19 cents.
- Report of the Entomologist for 1879. By J. Henry Comstock. (In Annual Report Commissioner of Agriculture for 1879. pp. 185-348, pls. 16.) Price 90 cents. Postage 20 cents.
- Report of the Entomologist for 1880. By J. Henry Comstock. pp. iv+235-373+iv, pls. 24. 1881. (Author's edition from the Annual Report of the Commissioner of Agriculture for 1880.) Out of print. Report of Commissioner for 1880. Price \$1.20. Postage 27 cents.
- Report on insects for the year 1881. By J. Henry Comstock. 1882. pp. 22, pls. XIV-XX. (Author's edition from the Annual Report of the Department of Agriculture for the year 1881. pp. 195-214, pls. XIV-XX.) Out of print.
- Report of the Entomologist, Charles V. Riley, for the fiscal year ending June 30, 1882. pp. viii+167, pls. 20. 1882. (Author's edition from the Annual Report of the Department of Agriculture for the year 1881[-82]. pp. 61-214, pls. 20.) Out of print. Report of Commissioner for 1881 and 1882. Price \$1.30. Postage 29 cents.
- Report of the Entomologist, Charles V. Riley, for the year 1883. pp. v+99-180+5+[2], pls. 13. 1883. (Author's edition from the Annual Report of the Department of Agriculture for 1883.) Out of print. Report of Commissioner for 1883. Price 60 cents. Postage 17 cents.
- Report of the Entomologist, Charles V. Riley, for the year 1884. pp. vii+[1]+134+2+ix, pls. 10. 1885. (Author's edition from the Annual Report of the Department of Agriculture for the year 1884.) Out of print. Report of Commissioner for 1884. Price \$1. Postage 20 cents.
- Report of the Entomologist, Charles V. Riley, for the year 1885. pp. vii+1+137+vi+2, 2 l., pls. 9, 1 map. 1886. (Author's edition from the Annual Report of the Department of Agriculture for the year 1885.) Out of print. Report of Commissioner for 1885. Price 80 cents. Postage 20 cents.
- Report of the Entomologist, Charles V. Riley, for the year 1886. pp. v+459-592+ix, pls. 11. 1887. (Author's edition from the Annual Report of the Department of Agriculture for the year 1886.) Out of print. Report of Commissioner for 1886. Price \$1. Postage 23 cents.
- Report of the Entomologist, Charles V. Riley, for the year 1887. pp. vi+48-179+vi, pls. 8. 1888. (Author's edition from the Annual Report of the Department of Agriculture for the year 1887.) Out of print. Report of Commissioner for 1887. Price \$1.20. Postage 23 cents.
- Report of the Entomologist, Charles V. Riley, for the year 1888. pp. iv+53-144, pls. 12. 1889. (Author's edition from the Annual Report of the Department of Agriculture for the year 1888.) Out of print. Report of Commissioner for 1888. Price \$1. Postage 23 cents.
- Report of the Entomologist for the year 1889. [By C. V. Riley.] pp. iv+331-361+iii, pls. 6. [1889?] (Author's edition from the Annual Report of the Department of Agriculture for the year 1889.) Out of print. Report of Secretary for 1889. Price 80 cents. Postage 18 cents.

- Report of the Entomologist for 1890. By C. V. Riley. pp. 1+237-264, pls. 7. 1891. (From the Report of the Secretary of Agriculture for 1890.) Out of print. Report of Secretary for 1890. Price \$1. Postage 20 cents.
- Report of the Entomologist for 1891. By C. V. Riley. pp. i-iii+231-266+ii. 1892. (From the Report of the Secretary of Agriculture for 1891.) Out of print. Report of Secretary for 1891. Price \$1. Postage 22 cents.
- Report of the Entomologist for 1892. By C. V. Riley. pp. i-iii+153-180+ii, pls. 12. 1893. (From the Report of the Secretary of Agriculture for 1892.) Out of print. Report of Secretary for 1892. Price \$1. Postage 22 cents.
- Report of the Entomologist for 1893. By C. V. Riley. pp. i-iii+199-226+ii, pls. 4. (From the Report of the Secretary of Agriculture for 1893.) Out of print. Report of Secretary for 1893. Price 80 cents. Postage 19 cents.
- Report of the Entomologist for 1894. By L. O. Howard. (In Annual Report Secretary of Agriculture in Message and Documents, 1893-1894. pp. 157-159.) Out of print.
- Report of the Entomologist for 1895. By L. O. Howard. (In Annual Report Secretary of Agriculture in Message and Documents, 1895. pp. 153-157.) Out of print.
- Report of the Entomologist for the fiscal year ending June 30, 1896. By L. O. Howard. pp. i-iii+89-93. 1896. (From the Report of the Secretary of Agriculture in Message and Documents, 1896.) Out of print.
- Report of the Entomologist for 1897. By L. O. Howard. pp. i-ii+111-116. 1897. (From the Report of the Secretary of Agriculture [1897].) Out of print.
- Report of the Entomologist for 1898. By L. O. Howard. pp. i-iii+17-25. 1898. (From the Report of the Secretary of Agriculture [1898].) Out of print.
- Report of the Entomologist for 1899. By L. O. Howard. pp. i-iii+43-52. 1899. (From the Report of the Secretary of Agriculture [1899].) Out of print.
- Report of the Entomologist for 1900. By L. O. Howard. pp. i-ii+27-34. 1900. (From Annual Reports, Department of Agriculture [1900].) Out of print.
- Report of the Entomologist for 1901. By L. O. Howard. pp. i-ii+141-150. 1901. (From Annual Reports, Department of Agriculture [1901].) Out of print.
- Report of the Acting Entomologist for 1902. By C. L. Marlatt. pp. i-iii+189-207. (From Annual Reports, Department of Agriculture [1902].) Out of print.
- Report of the Entomologist for 1903. By L. O. Howard. pp. i-ii+227-243. (From Annual Reports, Department of Agriculture [1903].) Out of print.
- Report of the Entomologist for 1904. By L. O. Howard. pp. i-iii+271-289. (From Annual Reports, Department of Agriculture [1904].) Out of print.
- Report of the Entomologist for 1905. By L. O. Howard. pp. i-ii+273-302. (From Annual Reports, Department of Agriculture [1905].) Out of print.
- Report of the Entomologist for 1906. By L. O. Howard. pp. 36. (From Annual Reports, Department of Agriculture [1906].) Issued Dec. 22, 1906. Out of print.
- Report of the Entomologist for 1907. By L. O. Howard. pp. 45. (From Annual Reports, Department of Agriculture [1907].) Issued Jan. 17, 1908. Out of print.
- Report of the Entomologist for 1908. By L. O. Howard. pp. 47. (From Annual Reports, Department of Agriculture [1908].) Issued Nov. 9, 1908.
- Report of the Entomologist for 1909. By L. O. Howard. pp. 45. (From Annual Reports, Department of Agriculture [1909].) Issued Dec. 2, 1909.

BULLETINS, OLD SERIES.

- No. 1. Reports of experiments, chiefly with kerosene, upon insects injuriously affecting the orange tree and the cotton plant, made under the direction of the Entomologist. pp. 62. 1883. Out of print.
- Same, second edition. pp. 62. 1883. Out of print.

- No. 1. Third edition. pp. 62. 1885. Out of print.
- No. 2. Reports of observations on the Rocky Mountain locust [*Melanoplus (Caloptenus) spretus* Uhl.] and chinch bug [*Blissus leucopterus* Say], together with extracts from the correspondence of the Division on miscellaneous insects. pp. 36. 1883. Out of print.
- Same, second edition. pp. 36. 1883. Out of print.
- No. 3. Reports of observations and experiments in the practical work of the Division, made under the direction of the Entomologist. pp. 75, pls. 3. 1883. Out of print.
- No. 4. Reports of observations and experiments in the practical work of the Division, made under the direction of the Entomologist, together with extracts from correspondence on miscellaneous insects. pp. 102, figs. 4. 1884. Out of print.
- No. 5. Descriptions of North American Chalcididae from the collections of the U. S. Department of Agriculture and of Dr. C. V. Riley, with biological notes. [First paper.] Together with a list of the described North American species of the family. By L. O. Howard. pp. 47. 1885. Out of print.
- No. 6. The imported elm leaf-beetle [*Galerucella luteola* Müll. (*Galeruca xanthomelæna* Schrank)]. Its habits and natural history, and means of counteracting its injuries. pp. 18, fig. 1, pl. 1. 1885. Out of print.
- Same, second edition. pp. 21, fig. 1, pl. 1. 1891. Price 5 cents. Postage 1 cent.
- No. 7. The Pediculi and Mallophaga affecting man and the lower animals. By Herbert Osborn. pp. 56, figs. 42. 1891. Price 10 cents. Postage 3 cents.
- No. 8. The periodical Cicada. An account of Cicada septendecim and its tredecim race, with a chronology of all the broods known. By Charles V. Riley. pp. 46, figs. 8. 1885. Out of print.
- Same, second edition. pp. 46. 1885. Out of print.
- No. 9. The mulberry silk-worm; being a manual of instructions in silk culture. By Charles V. Riley. Sixth revised edition. pp. 65, figs. 29, pls. 2. 1886. (Eds. 1-5 of Bulletin 9 are the same as "Special Report No. 11, Office of the Secretary.") Out of print.
- Same, seventh revised edition. pp. vii+65, figs. 29, pls. 2. 1888. Out of print.
- No. 10. Our shade trees and their insect defoliators. Being a consideration of the four most injurious species which affect the trees of the Capital, with means of destroying them. By Charles V. Riley. pp. 75, figs. 27. 1887. Out of print.
- Same, second revised edition. pp. 75, figs. 27. 1888. Out of print.
- No. 11. Reports of experiments with various insecticide substances, chiefly upon insects affecting garden crops, made under the direction of the Entomologist. pp. 34. 1886. Out of print.
- No. 12. Miscellaneous notes on the work of the Division of Entomology for the season of 1885, prepared by the Entomologist. pp. 46, pl. 1. 1886. Out of print.
- No. 13. Reports of observations and experiments in the practical work of the Division, made under the direction of the Entomologist. pp. 78, figs. 4. 1887. Out of print.
- No. 14. Reports of observations and experiments in the practical work of the Division, made under the direction of the Entomologist. pp. 62, figs. 2, pl. 1. 1887. Out of print.
- No. 15. The Icerya, or fluted scale, otherwise known as the cottony cushion-scale. [Reprint of some recent articles by the Entomologist, and of a report from the agricultural experiment station, University of California.] pp. 40. 1887. Out of print.
- No. 16. The entomological writings of Dr. Alpheus Spring Packard. By Samuel Henshaw. pp. 49. 1887. Out of print.
- No. 17. The chinch bug [*Blissus leucopterus* Say]: A general summary of its history, habits, enemies, and of the remedies and preventives to be used against it. By L. O. Howard. pp. 48, figs. 10. 1888. Price 5 cents. Postage 2 cents.

- No. 18. The life and entomological work of the late Townend Glover. By Charles Richards Dodge. pp. 68, figs. 5, pl. 1. 1888. Out of print.
- No. 19. An enumeration of the published synopses, catalogues, and lists of North American insects; together with other information intended to assist the student of American entomology. By E. A. Schwarz. pp. 77. 1888. Out of print.
- No. 20. The root-knot disease of the peach, orange, and other plants in Florida, due to the work of *Anguillula*. By J. C. Neal. pp. 31, pls. 21. 1889. Out of print.
- No. 21. Report of a trip to Australia, made under the direction of the Entomologist, to investigate the natural enemies of the fluted scale [*Icerya purchasi* Mask.]. By Albert Koebele. pp. 32, figs. 16. 1890. Out of print.
- Same*, revised edition. pp. 32, figs. 16. 1890. Out of print.
- No. 22. Reports of observations and experiments in the practical work of the Division, made under the direction of the Entomologist. pp. 110, figs. 2. 1890. Price 10 cents. Postage 4 cents.
- No. 23. Reports of observations and experiments in the practical work of the Division, made under the direction of the Entomologist. pp. 83. 1891. Out of print.
- No. 24. The bollworm of cotton [*Heliothis obsoleta* Fab. (*H. armigera* Hübn.)]. A report of progress in a supplementary investigation of this insect. By F. W. Mally. pp. 50, figs. 2. 1891. Out of print.
- No. 25. Destructive locusts. A popular consideration of a few of the more injurious locusts (or "grasshoppers") of the United States, together with the best means of destroying them. By C. V. Riley. pp. 62, figs. 11, pls. 12, map 1. 1891. Price 15 cents. Postage 3 cents.
- No. 26. Reports of observations and experiments in the practical work of the Division, made under the direction of the Entomologist. pp. 95. 1892. Out of print.
- No. 27. Reports on the damage by destructive locusts during the season of 1891, made under the direction of the Entomologist. pp. 64. 1892. Out of print.
- No. 28. The more destructive locusts of America north of Mexico. By Lawrence Bruner. pp. 40, figs. 21. 1893. Out of print.
- No. 29. Report on the boll worm of cotton [*Heliothis obsoleta* Fab. (*H. armigera* Hübn.)]. By F. W. Mally. pp. 73, pls. 2. 1893. Price 5 cents. Postage 3 cents.
- No. 30. Reports of observations and experiments in the practical work of the Division, made under the direction of the Entomologist. pp. 67. 1893. Out of print.
- No. 31. Catalogue of the exhibit of economic entomology at the World's Columbian Exposition, Chicago, Ill., 1893, made under the direction of the Entomologist. pp. 121. 1893. Price 10 cents. Postage 4 cents.
- No. 32. Reports of observations and experiments in the practical work of the Division, made under the direction of the Entomologist. pp. 59. 1894. Out of print.
- No. 33. Legislation against injurious insects; a compilation of the laws and regulations in the United States and British Columbia. By L. O. Howard. pp. 46. 1895. Out of print.

BULLETINS, NEW SERIES.

- No. 1. The honey bee: A manual of instruction in apiculture. By Frank Benton. pp. 118, figs. 76, pls. 11. 1896. Out of print.
- Same*, revised edition. pp. 118, figs. 76, pls. 12. 1896. Out of print.
- Same*, third edition. pp. 118, figs. 76, pls. 12. 1899. Price 15 cents. Postage 5 cents.
- Same*, 54th Cong., 1st sess., H. Doc. 359, serial No. 3435.
- No. 2. Proceedings of the seventh annual meeting of the Association of Economic Entomologists. pp. 100, fig. 1. 1895. Price 10 cents. Postage 4 cents.
- No. 3. The San Jose scale [*Aspidiotus perniciosus* Comst.]: Its occurrences in the United States, with a full account of its life history and the remedies to be used [Cir. 76]

- against it. By L. O. Howard and C. L. Marlatt. pp. 80, figs. 8. 1896. Price 10 cents. Postage 3 cents.
- No. 4. The principal household insects of the United States. By L. O. Howard and C. L. Marlatt. With a chapter on insects affecting dry vegetable foods. By F. H. Chittenden. pp. 130, figs. 64. 1896. Out of print.
- Same, revised edition. pp. 131, figs. 64. 1902 [1899]. Price 10 cents. Postage 5 cents.
- No. 5. Insects affecting domestic animals: An account of the species of importance in North America, with mention of related forms occurring on other animals. By Herbert Osborn. pp. 302, figs. 170, pls. 5. 1896. Price 20 cents. Postage 10 cents.
- No. 6. Proceedings of the eighth annual meeting of the Association of Economic Entomologists. pp. 100, figs. 5. 1896. Price 10 cents. Postage 4 cents.
- No. 7. Some miscellaneous results of the work of the Division of Entomology. Prepared under the direction of L. O. Howard, Entomologist. pp. 87, figs. 44. 1897. Price 10 cents. Postage 3 cents.
- No. 8. Some little-known insects affecting stored vegetable products: A collection of articles detailing certain original observations made upon insects of this class. By F. H. Chittenden. pp. 45, figs. 10. 1897. Out of print.
- No. 9. Proceedings of the ninth annual meeting of the Association of Economic Entomologists. pp. 87, figs. 2. 1897. Price 10 cents. Postage 4 cents.
- No. 10. Some miscellaneous results of the work of the Division of Entomology. Prepared under the direction of L. O. Howard, Entomologist. pp. 99, figs. 19. 1898. Price 10 cents. Postage 4 cents.
- No. 11. The gipsy moth in America: A summary account of the introduction and spread of *Porthetria dispar* in Massachusetts and of the efforts made by the State to repress and exterminate it. By L. O. Howard. pp. 39, figs. 8. 1897. Price 5 cents. Postage 2 cents.
- No. 12. The San Jose scale [*Aspidiotus perniciosus* Comst.] in 1896-1897. By L. O. Howard. pp. 31, fig. 1. 1898. Price 5 cents. Postage 2 cents.
- No. 13. Recent laws against injurious insects in North America, together with the laws relating to foul brood. Compiled by L. O. Howard. pp. 68. 1898. Price 5 cents. Postage 3 cents.
- No. 14. The periodical Cicada: An account of Cicada septendecim, its natural enemies, and the means of preventing its injury, together with a summary of the distribution of the different broods. By C. L. Marlatt. pp. 148, figs. 57, pls. 3. 1898. Price 15 cents. Postage 6 cents.
- No. 15. The chinch bug [*Blissus leucopterus* Say]: Its probable origin and diffusion, its habits and development, natural checks and remedial and preventive measures, with mention of the habits of an allied European species. By F. M. Webster. pp. 82, figs. 19. 1898. Out of print. (Superseded by No. 69.)
- No. 16. The Hessian fly [*Mayetiola (Cecidomyia) destructor* Say] in the United States. By Herbert Osborn. pp. 57, figs. 8, pls. 2, map 1. 1898. Price 10 cents. Postage 3 cents.
- No. 17. Proceedings of the tenth annual meeting of the Association of Economic Entomologists. pp. 104, figs. 4. 1898. Price 10 cents. Postage 4 cents.
- No. 18. Some miscellaneous results of the work of the Division of Entomology. III. Prepared under the direction of L. O. Howard, Entomologist. pp. 101, figs. 17. 1898. Price 10 cents. Postage 4 cents.
- No. 19. Some insects injurious to garden and orchard crops. A series of articles dealing with insects of this class. By F. H. Chittenden. pp. 99, figs. 20. 1899. Out of print.

- No. 20. Proceedings of the eleventh annual meeting of the Association of Economic Entomologists. pp. 111, figs. 4. 1899. Price 10 cents. Postage 4 cents.
- No. 21. Preliminary report on the insect enemies of forests in the Northwest. An account of the results gained from a reconnaissance trip made in the spring and early summer of 1899. By A. D. Hopkins. pp. 27. 1899. Out of print.
- No. 22. Some miscellaneous results of the work of the Division of Entomology. IV. Prepared under the direction of L. O. Howard, Entomologist. pp. 109, figs. 28. 1900. Price 10 cents. Postage 4 cents.
- No. 23. Some insects injurious to garden crops. A series of articles dealing with insects of this class. By F. H. Chittenden. pp. 92, figs. 23. 1900. Out of print.
- No. 24. A list of works on North American entomology. Compiled . . . by Nathan Banks. pp. 95. 1900. Price 10 cents. Postage 4 cents.
- No. 25. Notes on the mosquitoes of the United States: Giving some account of their structure and biology, with remarks on remedies. By L. O. Howard. pp. 70, figs. 22. 1900. Price 10 cents. Postage 3 cents.
- No. 26. Proceedings of the twelfth annual meeting of the Association of Economic Entomologists. pp. 102, pls. 2. 1900. Price 10 cents. Postage 4 cents.
- No. 27. Some insects injurious to the violet, rose, and other ornamental plants. A collection of articles dealing with insects of this class. By F. H. Chittenden. pp. 114, figs. 29, pls. 4. 1901. Out of print.
- Same*, revised edition. pp. 114, figs. 29, pls. 4. 1901. Price 10 cents. Postage 4 cents.
- No. 28. Insect enemies of spruce in the Northeast. A popular account of results of special investigations, with recommendations for preventing losses. . . . By A. D. Hopkins. pp. 80, figs. 2, pls. 16. 1901. Price 10 cents. Postage 5 cents.
- No. 29. The fall army worm [*Laphygma frugiperda* S. & A.] and variegated cutworm [*Peridroma margaritosa* Haw. (*saucia* Hübn.)]. By F. H. Chittenden. pp. 64, figs. 11. 1901. Price 5 cents. Postage 3 cents.
- No. 30. Some miscellaneous results of the work of the Division of Entomology. V. Prepared under the direction of L. O. Howard, Entomologist. pp. 98, figs. 29, pls. 2. 1901. Price 10 cents. Postage 4 cents.
- No. 31. Proceedings of the thirteenth annual meeting of the Association of Economic Entomologists [1901]. pp. 103, figs. 4, pls. 2. 1902. Price 10 cents. Postage 4 cents.
- No. 32. Insect enemies of the pine in the Black Hills Forest Reserve. An account of results of special investigations, with recommendations for preventing losses. By A. D. Hopkins. pp. 24, figs. 5, pls. 7. 1902. Price 10 cents. Postage 2 cents.
- No. 33. Some insects injurious to vegetable crops. A series of articles dealing with insects of this class. By F. H. Chittenden. pp. 117, figs. 30. 1902. Out of print.
- No. 34. The principal insects liable to be distributed on nursery stock. By Nathan Banks. pp. 46, figs. 47. 1902. Price 5 cents. Postage 2 cents.
- No. 35. Report on codling-moth [*Carpocapsa pomonella* L.] investigations in the Northwest during 1901. By C. B. Simpson. pp. 29, fig. 1, pls. 5. 1902. Price 10 cents. Postage 2 cents.
- No. 36. An index to Bulletins Nos. 1-30 (new series) (1896-1901) of the Division of Entomology. By Nathan Banks. pp. 64. 1902. Price 5 cents. Postage 3 cents.
- No. 37. Proceedings of the fourteenth annual meeting of the Association of Economic Entomologists. pp. 127, figs. 2, pl. 1. 1902. Price 10 cents. Postage 5 cents.
- No. 38. Some miscellaneous results of the work of the Division of Entomology. VI. Prepared under the direction of the Entomologist. pp. 110, figs. 9, pls. 2. 1902. Price 10 cents. Postage 4 cents.
- No. 39. The culture of the mulberry silkworm [*Bombyx mori* L.]. By Henrietta Aiken Kelly. pp. 32, figs. 15. 1903. Out of print.

- No. 40. Proceedings of the fifteenth annual meeting of the Association of Economic Entomologists. pp. 124, figs. 6, pls. 2. 1903. Price 10 cents. Postage 5 cents.
- No. 41. The codling moth [*Carpocapsa pomonella* L.]. By C. B. Simpson. pp. 105, figs. 19, pls. 16. 1903. Price 15 cents. Postage 5 cents.
- No. 42. Some insects attacking the stems of growing wheat, rye, barley, and oats, with methods of prevention and suppression. By F. M. Webster. pp. 62, figs. 15. 1903. Price 5 cents. Postage 3 cents.
- No. 43. A brief account of the principal insect enemies of the sugar beet. By F. H. Chittenden. pp. 71, figs. 65. 1903. Price 5 cents. Postage 3 cents.
- No. 44. Some miscellaneous results of the work of the Division of Entomology. VII. Prepared under the direction of the Entomologist. pp. 99, figs. 19, pl. 1. 1904. Price 10 cents. Postage 4 cents.
- No. 45. The Mexican cotton boll weevil [*Anthonomus grandis* Boh.]. By W. D. Hunter and W. E. Hinds. pp. 116, figs. 6, pls. 16. 1904. Price 25 cents. Postage 6 cents.
- No. 46. Proceedings of the sixteenth annual meeting of the Association of Economic Entomologists. pp. 113, fig. 1, pls. 2. 1904. Price 10 cents. Postage 4 cents.
- No. 47. Catalogue of the exhibit of economic entomology at the Louisiana Purchase Exposition, St. Louis, Mo., 1904 . . . By E. S. G. Titus and F. C. Pratt. pp. 155. 1904. Out of print.
- Same, revised edition. 1904. Price 10 cents. Postage 5 cents.
- No. 48. Catalogue of exhibits of insect enemies of forests and forest products at the Louisiana Purchase Exposition, St. Louis, Mo., 1904. By A. D. Hopkins. pp. 56, pls. 22. 1904. Price 15 cents. Postage 4 cents.
- No. 49. Report on the habits of the kelep, or Guatemalan cotton-boll-weevil ant. By O. F. Cook. pp. 15. 1904. Price 5 cents. Postage 1 cent.
- No. 50. The cotton bollworm [*Heliothis obsoleta* Fab.]. By A. L. Quaintance and C. T. Brues. pp. 155, figs. 27, pls. 25, map 1. 1905. Price 25 cents. Postage 8 cents.
- No. 51. The Mexican cotton boll weevil [*Anthonomus grandis* Boh.]. A revision and amplification of Bulletin 45, to include the most important observations made in 1904. By W. D. Hunter and W. E. Hinds. pp. 181, figs. 8, pls. 23. 1905. Price 15 cents. Postage 8 cents.
- Same, 58th Cong., 3d sess., H. Doc. 383.
- No. 52. Proceedings of the seventeenth annual meeting of the Association of Economic Entomologists. pp. 123, figs. 7. 1905. Price 10 cents. Postage 4 cents.
- No. 53. Catalogue of the exhibit of economic entomology at the Lewis and Clark Centennial Exposition, Portland, Oregon, 1905 . . . By Rolla P. Currie. pp. 127. 1905. Price 10 cents. Postage 5 cents.
- No. 54. Some miscellaneous results of the work of the Bureau of Entomology. VIII. Prepared under the direction of the Entomologist. pp. 99, figs. 20, pls. 4. 1905. Price 10 cents. Postage 4 cents.
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Same, revise. pp. 4, figs. 3. Issued June 12, 1907.
- No. 35. House flies (*Musca domestica* et al.). By L. O. Howard. pp. 8, figs. 6. July 11, 1898. Out of print. (Superseded by No. 71.)
- No. 36. The true clothes moths (*Tinea pellionella* et al.). By C. L. Marlatt. pp. 8, figs. 3. July 18, 1898. Out of print.
Same, revise. pp. 8, figs. 3. Issued January 15, 1908.
- No. 37. The use of hydrocyanic-acid gas for fumigating greenhouses and cold frames. By Albert F. Woods and P. H. Dorsett. pp. 10, figs. 3. January 10, 1899. Out of print.
Same, corrected print. (Compare page 8.) pp. 10, figs. 3. January 10, 1899. Out of print.
Same, revised edition. pp. 10, figs. 3. October 2, 1903. Out of print.
Same, second revise. pp. 11, figs. 3. Issued April 3, 1908.
- No. 38. The squash-vine borer (*Melittia satyriniformis* Hbn.). By F. H. Chittenden. pp. 6, figs. 2. April 22, 1899. Out of print.
Same, revised edition. pp. 6, figs. 2. November 19, 1903. Out of print.
Same, second revise. pp. 6, figs. 2. Issued September 3, 1908.
- No. 39. The common squash bug (*Anasa tristis* De G.). By F. H. Chittenden. pp. 5, figs. 3. May 5, 1899. Out of print.
Same, revised edition. pp. 5, figs. 3. March 23, 1905. Out of print.
Same, second revise. pp. 5, figs. 3. Issued July 28, 1908.
- No. 40. How to distinguish the different mosquitoes of North America. By L. O. Howard (with synoptical tables of the North American mosquitoes; by D. W. Coquillett). pp. 8, figs. 3. February 20, 1900. Out of print.

- No. 40. Second print. pp. 8, figs. 3. [1901.] Out of print.
- No. 41. Regulations of foreign governments regarding importation of American plants, trees, and fruits. By L. O. Howard. pp. 4. August 24, 1900.
- No. 42. How to control the San Jose scale. By C. L. Marlatt. pp. 6. October 22, 1900. Out of print.
- Same*, revised. pp. 6. May 17, 1902. Out of print.
- Same*, second edition. May 26, 1902. Out of print.
- Same*, third edition. April 6, 1903. Out of print.
- Same*, fourth edition. pp. 8. March 10, 1906. Out of print.
- Same*, fifth edition. pp. 7. [March 31] 1909.
- No. 43. The destructive green pea louse (*Nectarophora destructor* Johns.). By F. H. Chittenden. pp. 8, figs. 3. May 23, 1901. Out of print.
- Same*, second edition [entitled "The pea aphid (*Macrosiphum pisi* Kalt.)"]. pp. 10, figs. 7. Issued February 25, 1909.
- No. 44. The periodical cicada in 1902. By W. D. Hunter. pp. 4, figs. 2. March 13, 1902. Out of print.
- No. 45. A new nomenclature for the broods of the periodical cicada. By C. L. Marlatt. pp. 8. May 1, 1902. Out of print.
- No. 46. Hydrocyanic-acid gas against household insects. By L. O. Howard. pp. 6. June 22, 1902. Out of print.
- Same*, revised edition. pp. 7. Issued February 20, 1907. Revised by C. L. Marlatt.
- No. 47. The bedbug (*Cimex lectularius* Linn.). By C. L. Marlatt. pp. 8, figs. 3. June 15, 1902. Out of print.
- Same*, revised edition. pp. 8, figs. 3. Issued February 26, 1907.
- No. 48. The house centipede (*Scutigera forceps* Raf.). By C. L. Marlatt. pp. 4, figs. 2. June 10, 1902.
- No. 49. The silver fish (*Lepisma saccharina* Linn.). By C. L. Marlatt. pp. 4, figs. 2. June 20, 1902.
- No. 50. The white ant (*Termes flavipes* Koll.). By C. L. Marlatt. pp. 8, figs. 4. June 30, 1902. Out of print.
- Same*, revised edition. pp. 8, figs. 4. Issued January 27, 1908.
- No. 51. Cockroaches. By C. L. Marlatt. pp. 15, figs. 5. June 23, 1902. Out of print.
- Same*, revised edition. pp. 14, figs. 5. Issued June 23, 1908.
- No. 52. The lime, sulphur, and salt wash. By C. L. Marlatt. pp. 8. February 20, 1903. Out of print.
- Same*, second edition. March 18, 1904. Out of print.
- No. 53. The yellow-winged locust (*Comnula pellucida* Scudd.). By C. B. Simpson. pp. 3, fig. 1. May 12, 1903.
- No. 54. The peach-tree borer (*Sannina exitiosa* Say). By C. L. Marlatt. pp. 6, fig. 1. October 19, 1903.
- No. 55. Powder-post injury to seasoned wood products. By A. D. Hopkins. pp. 5, fig. 1. November 20, 1903.
- No. 56. The most important step in the cultural system of controlling the boll weevil. By W. D. Hunter. pp. 7. October 10, 1904. (Superseded by No. 95.)
- No. 57. The greenhouse white fly (*Aleyrodes vaporariorum* Westw.). By A. W. Morrill. pp. 9, fig. 1. February 15, 1905.
- No. 58. Report on the gypsy moth and the brown-tail moth, July, 1904. By C. L. Marlatt. pp. 12, pl. 1, map 1. March 21, 1905. Out of print.
- No. 59. The corn root-worms. By F. H. Chittenden. pp. 8, figs. 3. March 23, 1905.
- No. 60. The imported cabbage worm (*Pontia rapæ* Linn.). By F. H. Chittenden. pp. 8, figs. 6. April 28, 1905.

- No. 61. Black check in western hemlock. By H. E. Burke. pp. 10, figs. 5. May 24, 1905.
- No. 62. The cabbage hair-worm. By F. H. Chittenden. pp. 6, fig. 1. May 17, 1905. Out of print.
- Same*, revised edition. pp. 6, fig. 1. Issued July 28, 1908.
- No. 63. Root-maggots and how to control them. By F. H. Chittenden. pp. 7, figs. 5. June 6, 1905. Out of print.
- Same*, second edition. pp. 7, figs. 5. February 12, 1906.
- No. 64. The cottony maple scale (*Pulvinaria innumerabilis* Rathvon). By J. G. Sanders. pp. 6, figs. 4. September 7, 1905.
- No. 65. The cotton red spider (*Tetranychus gloveri* Bks.). By E. S. G. Titus. pp. 5, figs. 2. October 30, 1905.
- No. 66. The joint-worm (*Isosoma tritici* Fitch). By F. M. Webster. pp. 5, figs. 5. October 20, 1905. Out of print.
- Same*, revised edition. pp. 7, figs. 6. Issued September 21, 1908.
- No. 67. The clover root-borer (*Hylastinus obscurus* Marsham). By F. M. Webster. pp. 5, figs. 4. December 28, 1905.
- No. 68. The tobacco thrips and remedies to prevent "white veins" in wrapper tobacco (*Euthrips nicotianæ* Hinds). By W. A. Hooker. pp. 5, figs. 2. February 26, 1906.
- No. 69. Some insects affecting the production of red clover seed. By F. M. Webster. pp. 9, figs. 8. April 12, 1906.
- No. 70. The Hessian fly (*Mayetiola* [*Cecidomyia*] *destructor* Say). By F. M. Webster. pp. 16, figs. 16. April 14, 1906.
- No. 71. (Revision of Circular No. 35.) House flies (*Musca domestica* et al.). By L. O. Howard. pp. 9, figs. 9. March 27, 1906. Out of print.
- Same*, revised edition. pp. 10, figs. 9. September 21, 1906.
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- No. 74. The periodical cicada in 1906. By C. L. Marlatt. pp. 5, figs. 3. April 16, 1906.
- No. 75. Requirements to be complied with by nurserymen or others who make interstate shipments of nursery stock. By A. F. Burgess. pp. 6. July 5, 1906. Out of print.
- Same*, revised edition. pp. 7. Issued July 24, 1908. Out of print.
- Same*, second revision. pp. 9. Issued August 7, 1909.
- No. 76. List of publications of the Bureau of Entomology. Compiled by Mabel Colcord. pp. 21. September 24, 1906. Out of print.
- Same*, revised to March 1, 1908. pp. 28. Out of print.
- Same*, revised to May 1, 1909, pp. 29. Out of print.
- Same*, revised to February 1, 1910. pp. 32.
- No. 77. Harvest mites, or "chiggers." By F. H. Chittenden. pp. 6, figs. 3. September 29, 1906.
- No. 78. The slender seed-corn ground-beetle (*Clivina impressifrons* Lec.). By F. M. Webster. pp. 5, figs. 2. October 4, 1906. Out of print.
- No. 79. The brood diseases of bees. By E. F. Phillips. pp. 5. October 3, 1906.
- No. 80. The melon aphid (*Aphis gossypii* Glov.). By F. H. Chittenden. pp. 16, figs. 6. November 14, 1906.
- No. 81. The aphides affecting the apple. By A. L. Quaintance. pp. 10, figs. 8. Issued March 9, 1907.
- No. 82. Pinhole injury to girdled cypress in the South Atlantic and Gulf States. By A. D. Hopkins. pp. 4, fig. 1. Issued January 2, 1907.

- No. 83. The locust borer [*Cyrtene robiniae* Forst.] and methods for its control. By A. D. Hopkins. pp. 8, figs. 4. Issued February 19, 1907.
- No. 84. The grasshopper problem and alfalfa culture. By F. M. Webster. pp. 10, figs. 8. Issued April 6, 1907.
- No. 85. The spring grain-aphis (*Toxoptera graminum* Rond.). By F. M. Webster. pp. 7, figs. 3. Issued March 29, 1907. (See also No. 93.)
- No. 86. The corn leaf-aphis [*Aphis maidis* Fitch] and corn root-aphis [*Aphis maidi-radidis* Forbes]. By F. M. Webster. pp. 13, figs. 4. Issued May 6, 1907.
- No. 87. The Colorado potato beetle (*Leptinotarsa decemlineata* Say). By F. H. Chittenden. pp. 15, figs. 6. Issued June 3, 1907.
- No. 88. The terrapin scale (*Eulecanium nigrofasciatum* Pergande.). By J. G. Sanders. pp. 4, figs. 3. Issued May 14, 1907.
- No. 89. The periodical cicada in 1907 (*Tibicen septendecim* L., race *tredecim* Walsh-Riley). By C. L. Marlatt. pp. 4, figs. 3. Issued May 14, 1907.
- No. 90. The white-pine weevil [*Pissodes strobi* Peck]. By A. D. Hopkins. pp. 8, figs. 6. Issued June 18, 1907.
- No. 91. Note on the occurrence of the North American fever tick [*Margaropus* (*Boophilus*) *annulatus* Say] on sheep. By W. D. Hunter. pp. 3. Issued July 3, 1907.
- No. 92. Mites and lice on poultry. By Nathan Banks. pp. 88, figs. 6. Issued September 25, 1907.
- No. 93. The spring grain-aphis or so-called "green bug" (*Toxoptera graminum* Rond.). By F. M. Webster. pp. 18, figs. 7. Issued August 22, 1907. Out of print.
- Same*, revised. pp. 22, figs. 10. Issued June 23, 1909.
- No. 94. The cause of American foul brood [*Bacillus larvæ*]. By G. F. White. pp. 4. Issued July 29, 1907.
- No. 95. (Revision of Circular No. 56.) The most important step in the control of the boll weevil [*Anthonomus grandis* Boh.]. By W. D. Hunter. pp. 8. Issued October 3, 1907. Out of print.
- Same*, revised edition. pp. 8. Issued September 21, 1908.
- Same*, French edition. pp. 11. Issued January 21, 1909.
- No. 96. The catalpa sphinx (*Ceratonia catalpæ* Bdv.). By L. O. Howard and F. H. Chittenden. pp. 7, figs. 2. Issued December 16, 1907.
- No. 97. The bagworm (*Thyridopteryx ephemæformis* Haw.). By L. O. Howard and F. H. Chittenden. pp. 10, figs. 11. Issued February 6, 1908.
- No. 98. The apple-tree tent caterpillar (*Malacosoma americana* Fab.). By A. L. Quaintance. pp. 8, figs. 4. Issued January 28, 1908.
- No. 99. The nut weevils.^a By F. H. Chittenden. pp. 15, figs. 14. Issued March 6, 1908.
- No. 100. (In preparation.)
- No. 101. The apple maggot or "railroad worm" (*Rhagoletis* [*Trypeta*] *pomonella* Walsh). By A. L. Quaintance. pp. 12, figs. 2. Issued May 4, 1908.
- No. 102. The asparagus beetles. By F. H. Chittenden. pp. 12, figs. 7. Issued May 20, 1908.
- No. 103. The harlequin cabbage bug (*Murgantia histrionica* Hahn). By F. H. Chittenden. pp. 10, fig. 1. Issued June 20, 1908.
- No. 104. The common red spider (*Tetranychus bimaculatus* Harvey). By F. H. Chittenden. pp. 11, figs. 4. Issued January 26, 1909.
- No. 105. The rose slugs. By F. H. Chittenden. pp. 12, figs. 5. Issued October 5, 1908.
- No. 106. The wheat strawworm (*Isosoma grande* Riley). By F. M. Webster. pp. 15, figs. 13. Issued May 13, 1909.

^a Reprinted from Yearbook of the Department of Agriculture for 1904. pp. 299-310, pls. XXVIII-XXX, figs. 17-26.

- No. 107. What can be done in destroying the cotton boll weevil during the winter. By W. D. Hunter. pp. 4. Issued January 12, 1909.
- No. 108. House fleas. By L. O. Howard. pp. 4, figs. 2. Issued February 11, 1909.
- No. 109. The leopard moth (*Zeuzera pyrina* Fab.). By L. O. Howard and F. H. Chittenden. pp. 8, figs. 2. Issued July 6, 1909.
- No. 110. The green-striped maple worm (*Anisota rubicunda* Fab.). By L. O. Howard and F. H. Chittenden. pp. 7, figs. 3. Issued July 10, 1909.
- No. 111. Preparations for winter fumigation for the citrus white fly [*Aleyrodes citri* Riley and Howard]. By A. W. Morrill and W. W. Yothers. pp. 12, figs. 4. Issued September 29, 1909.
- No. 112. (In preparation.)
- No. 113. The chinch bug (*Blissus leucopterus* Say). By F. M. Webster. pp. 27, figs. 8. Issued November 13, 1909.
- No. 114. The Euonymus scale (*Chionaspis euonymi* Comstock.) By J. G. Sanders. pp. 5, figs. 2. Issued November 24, 1909.

TECHNICAL SERIES.

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- No. 2. The grass and grain joint-worm flies and their allies: A consideration of some North American phytophagic Eurytominae. By L. O. Howard. pp. 24, figs. 10. 1896. Out of print.
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- No. 6. The San Jose scale [*Aspidiotus perniciosus* Comst.] and its nearest allies. A brief consideration of the characters which distinguish these closely related scale insects. By T. D. A. Cockerell. pp. 31, figs. 15. 1897. Out of print.
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- No. 9. The life history of two species of plant-lice [*Hormaphis hamamelidis* Fitch and *Hamamelistes spinosus* Shimer] inhabiting both the witch-hazel and birch. By Theo. Pergande. pp. 44, figs. 23. 1901. Price 5 cents. Postage 2 cents.
- No. 10. The social organization and breeding habits of the cotton-protecting kelep of Guatemala [*Ectatomma tuberculatum* Oliv.]. By O. F. Cook. pp. 55. 1905. Price 5 cents. Postage 3 cents.
- No. 11. A classification of the mosquitoes of North and Middle America. By D. W. Coquillett. pp. 31, fig. 1. 1906. Price 5 cents. Postage 2 cents.
- No. 12, Part I. Miscellaneous papers. Catalogue of recently described Coccidae. By J. G. Sanders. pp. 1-18. June 5, 1906. Price 10 cents. Postage 2 cents.

- No. 12, Part II. Miscellaneous papers. Habits and life histories of some flies of the family Tabanidæ. By James S. Hine. pp. iv+19-38, figs. 1-12. August 29, 1906. Price 10 cents. Postage 2 cents.
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- No. 12, Part IV. (Supplement to Technical Series No. 1.) Miscellaneous papers. New genera and species of Aphelininæ, with a revised table of genera. By L. O. Howard. pp. iv+69-88, figs. 13-22. Issued July 12, 1907. Price 5 cents. Postage 1 cent.
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- No. 12, Part VI. Miscellaneous papers. A record of results from rearings and dissections of Tachinidæ. By Charles H. T. Townsend. pp. iv+95-118, figs. 25-30. Issued September 18, 1908. Price 5 cents. Postage 2 cents.
- No. 12, Part VII. Miscellaneous papers. The orange thrips. By Dudley Moulton. pp. ii+119-122, pl. VIII. Issued February 11, 1909. Price 5 cents. Postage 1 cent.
- No. 12, Part VIII. Miscellaneous papers. Biological studies on three species of Aphididæ. By John June Davis. pp. ii+123-168, figs. 31-34. Issued February 20, 1909. Price 10 cents. Postage 2 cents.
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- No. 16, Part II. Papers on Coccidæ or scale insects. New species of Diaspine scale insects. By C. L. Marlatt. pp. ii+11-32, pls. I-IX. Issued August 5, 1908. Price 15 cents. Postage 2 cents.
- No. 16, Part III. Papers on Coccidæ or scale insects. Catalogue of recently described Coccidæ. II.^a By J. G. Sanders. pp. ii+33-60. Issued December 22, 1909. Price 5 cents. Postage 2 cents.
- No. 17, Part I. Contributions toward a monograph of the scolytid beetles. I. The genus *Dendroctonus*. By A. D. Hopkins. pp. xiv+1-164, figs. 1-95, pls. I-VIII. Issued June 30, 1909. Price 25 cents. Postage 7 cents.
- No. 18. (In preparation.)
- No. 19, Part I. Technical results from the Gipsy Moth Parasite Laboratory. I. The parasites reared or supposed to have been reared from the eggs of the gipsy moth. By L. O. Howard. pp. vi+1-12, figs. 1-7. Issued January 28, 1910. Price 5 cents. Postage 1 cent.

^aCatalogue of recently described Coccidæ, I, was published as Technical Series 12. Part I.

SPECIAL REPORTS.

- Bibliography of the more important contributions to American economic entomology. Prepared by Samuel Henshaw. Part I. The more important writings of Benjamin Dann Walsh. pp. 49. 1889. Out of print.
- Bibliography of the more important contributions to American economic entomology. Part II. The more important joint writings of B. D. Walsh and C. V. Riley. pp. 51-96. 1889. Out of print.
- Bibliography of the more important contributions to American economic entomology. Part III. The more important writings of Charles Valentine Riley. pp. 97-371. 1889. Out of print.
- Bibliography of the more important contributions to American economic entomology. Index to Parts I, II, and III. pp. 1+373-454. 1890. Out of print.
- Same*, 51st Cong., 1st sess., H. Mis. Doc. 133, serial No. 2768.
- Bibliography of the more important contributions to American economic entomology. Part IV. By Samuel Henshaw. The more important writings of Government and State entomologists, and of other contributors to the literature of American economic entomology. A-K. pp. 167. 1895. Out of print.
- Bibliography of the more important contributions to American economic entomology. Part V. By Samuel Henshaw. The more important writings of Government and State entomologists, and of other contributors to the literature of American economic entomology. L-Z. pp. 179. 1896. Out of print.
- Bibliography of the more important contributions to American economic entomology. Part VI. The more important writings published between June 30, 1888, and December 30, 1896. Prepared under the direction of the Entomologist, by Nathan Banks, Assistant. pp. 273. 1898. Out of print.
- Bibliography of the more important contributions to American economic entomology. Part VII. The more important writings published between December 31, 1896, and January 1, 1900. Prepared under the direction of the Entomologist, by Nathan Banks, Assistant. pp. 113. 1901. Price, cloth, 20 cents. Postage 3 cents.
- Bibliography of the more important contributions to American economic entomology. Part VIII. The more important writings published between December 31, 1899, and January 1, 1905. Prepared under the direction of the Entomologist, by Nathan Banks, Assistant Entomologist. pp. 132. 1905. Price 10 cents. Postage 3 cents.

UNITED STATES ENTOMOLOGICAL COMMISSION.

[Members of the Commission: C. V. Riley, A. S. Packard, and Cyrus Thomas. The Commission was attached to the United States Geological and Geographical Survey of the Territories, Department of the Interior, until March 3, 1881. The third report of the Commission inaugurated its transfer to the Department of Agriculture. Of the Bulletins, Nos. 1 and 2 were made under direction of the United States Geological and Geographical Survey of the Territories (Hayden); Nos. 3-7 under direction of the Interior Department; none was issued under the Agricultural Department.]

BULLETINS.

- No. 1. Destruction of the young or unfledged locusts [*Melanoplus (Caloptenus) spretus* Uhl.]. pp. 12. 1877. Out of print.
- No. 2. On the natural history of the Rocky Mountain locust [*Melanoplus (Caloptenus) spretus* Uhl.], and on the habits of the young or unfledged insects as they occur in the more fertile country in which they will hatch the present year. pp. 14, figs. 10, map 1. 1877. Out of print.
- No. 3. The cotton worm [*Alabama (Alectia) argillacea* Hübn.]. Summary of its natural history, with an account of its enemies, and the best means of controlling it; being

- a report of progress of the work of the Commission. By C. V. Riley. pp. 144, figs. 84, pl. 1. 1880. Out of print.
- No. 4. The Hessian fly [*Mayetiola (Cecidomyia) destructor* Say]. Its ravages, habits, enemies, and means of preventing its increase. By A. S. Packard. pp. 43, fig. 1, pls. 2, map 1. 1880. Out of print.
- No. 5. The chinch-bug [*Blissus leucopterus* Say]. Its history, characters, and habits, and the means of destroying it or counteracting its injuries. By Cyrus Thomas. pp. 44, figs. 10, map 1. 1879. Out of print.
- No. 6. General index and supplement to the nine reports on the insects of Missouri. By Charles V. Riley. pp. 177. 1881. Out of print.
- No. 7. Insects injurious to forest and shade trees. By A. S. Packard. pp. 275, figs. 100. 1881. Out of print.

REPORTS.

- First annual report, for the year 1877, relating to the Rocky Mountain locust [*Melanoplus (Caloptenus) spretus* Uhl.] and the best methods of preventing its injuries and of guarding against its invasions, in pursuance of an appropriation made by Congress for this purpose. With maps and illustrations. pp. xvi+477+294, figs. 111, pls. 5, maps 2. 1878. Out of print.
- Second report, for the years 1878 and 1879, relating to the Rocky Mountain locust [*Melanoplus (Caloptenus) spretus* Uhl.] and the western cricket [*Anabrus simplex* Hald.], and treating of the best means of subduing the locust in its permanent breeding grounds, with a view of preventing its migrations into the more fertile portions of the trans-Mississippi country, in pursuance of appropriations made by Congress for this purpose. With maps and illustrations. pp. xviii+322+80, figs. 10, pls. 17, maps 7. 1880. Out of print.
- Third report, relating to the Rocky Mountain locust, the western cricket, the army worm, canker worms, and the Hessian fly, together with descriptions of larvæ of injurious forest insects, studies of embryological development of the locust and of other insects, and on the systematic position of the Orthoptera in relation to other orders of insects. With maps and illustrations. pp. xiv+347+12+92, figs. 14, pls. 64, maps 3. 1883. Price, cloth, \$1. Postage 20 cents.
- Same, 47th Cong., 2d sess., H. Mis. Doc. 44, serial No. 2154.
- Fourth report, being a revised edition of Bulletin No. 3, and the final report on the cotton worm [*Alabama (Aletia) argillacea*], together with a chapter on the boll worm [*Heliothis obsoleta* Fab. (*H. armigera* Hübn.)]. By Charles V. Riley. With maps and illustrations. pp. xxxviii+399+147, figs. 45, pls. 64, maps 2. 1883. Price \$1.25. Postage 22 cents.
- Same, 48th Cong., 2d sess., H. Mis. Doc. 39, serial No. 2325.
- Fifth report, being a revised and enlarged edition of Bulletin No. 7, on Insects injurious to forest and shade trees. By Alpheus S. Packard. pp. viii+957, figs. 306, pls. 40. 1890. Out of print.
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DIVISION OF ENTOMOLOGY, SILK SECTION.

[Discontinued June 30, 1891.]

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- No. 68. The chemical composition of insecticides and fungicides, with an account of methods of analysis employed. By J. K. Haywood. pp. 62. 1902. Price 5 cents. Postage 3 cents.
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- No. 101. The lime-sulphur-salt wash and its substitutes. By J. K. Haywood. pp. 29. Issued February 28, 1907. Price 5 cents. Postage 2 cents.
- No. 110. Chemical analysis and composition of American honeys, by C. A. Browne, including a microscopical study of honey pollen, by W. J. Young. pp. 93, fig. 1, pls. 6. Issued March 14, 1908. Price 30 cents. Postage 5 cents.

CIRCULAR.

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Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., January 11, 1910.

[Cir. 76]

CIRCULAR NO. 77.

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

HARVEST MITES, OR "CHIGGERS."

By F. H. CHITTENDEN,

Entomologist in Charge of Breeding Experiments.

Residents of the South and of the more southern portion of many of the Central States, and especially visitors to these sections, are often subject to great annoyance due to the attacks of minute creatures popularly known as "chiggers"¹ and "red bugs," and, incorrectly, as ticks. These pests are the larval or six-legged forms of harvest mites of the genus *Trombidium*, the adults of which have eight legs. They are troublesome because of their unpleasant habit of burrowing under the skin of human beings. This habit is not normal, and as a consequence the mites die, and their presence under the epidermis gives rise to irritation and inflammation of varying intensity.

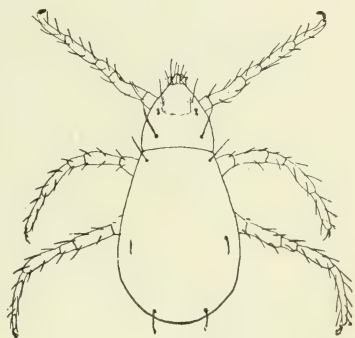


FIG. 1.—*Trombidium*: Larva, highly magnified (from Banks).

For present purposes we may consider the harvest mites as a class. In figures 1 and 2 illustrations of some common forms are furnished. The larval harvest mites are of microscopic size, blood red, and shaped somewhat like a common tick, being nearly as broad in front as behind. They belong to the order Acarina and are not true insects (Hexapoda), but are members of a distinct class (Arachnida) along with ticks, spiders, and the like. The parent mites are predaceous on true insects. As early as 1834 Mr. A. L. Dugès² made observations on these mites, which, as previously stated, have six legs in the immature or parasitic stage, while the adults have eight. The adults are of different shades of red and are quite visible. Many persons are familiar with the appearance of the young of certain species,

¹The name "chigger" or "jigger" is evidently a corruption of chigoe, the pernicious sand-flea (*Sarcopsylla penetrans* L.) of tropical America, a true flea, which crawls under the toe nails of man, producing painful sores which may result seriously if neglected.

²Annales des Sciences Naturelles, Vol. I, ser. 1, p. 36; see also P. Megnin, l. c., Vol. IV, ser. 6, pp. 4-20, 1876, and Murray's Aptera, pp. 129-133.

as they occur on the under surface of the bodies of grasshoppers and harvest spiders or "daddy long legs" (Phalangiidæ) and under the wings of the house fly. Just what species of harvest mites are troublesome to man in the United States is not known, but one of them, perhaps the commonest, is referred to in literature as "*Leptus*" *irritans* Riley.¹

SYMPTOMS AND MANNER OF ATTACK.

Soon after the harvest mite burrows under the human skin a small red spot appears (evidently the mite itself gorged with human blood), after which the surrounding surface becomes congested, the affected area spreading until it is from less than a quarter to a half or three-fourths of an inch in diameter. This congestion may manifest itself within less than an hour after exposure or may not be apparent for twelve

hours or so, the fever being at its height usually on the second day. The symptoms are apt to be first noticed when the sufferer has removed his clothing at night, or upon awakening from sleep. It sometimes happens that there is little irritation until some time after exposure, but with most persons susceptible to the poison-



FIG. 2.—*Leptus americanus* at left; *Leptus irritans* at right. Highly magnified, dots under anal extremity indicating natural size (after Riley).

ous effects of these mites irritation is first experienced on the second day. The feverish appearance of the afflicted skin area varies according to the susceptibility of the person attacked. Children dwelling or sojourning in mite-infested localities suffer greatly from these pests, experienc-

¹ Riley, Poisonous Insects, Extr. Ref. Handb. Med. Sci., Vol. V, 1887, p. 745.

Leptus is a genus founded on the larval Trombidium. For those who may desire further information in regard to the structure of the adult, the following paragraph is transcribed from "A Treatise on the Acarina or Mites," by Nathan Banks (Proc. U. S. Nat. Mus., Vol. XXVIII, pp. 30, 31, 1904), together with a figure illustrating a common species:

The "harvest mites" * * * are recognized by the body being divided into two portions, the anterior (cephalothorax) bearing the two anterior pairs of legs, the palpi, mouth parts, and eyes. The posterior (abdomen) is much larger and bears the two posterior pairs of legs. The mandibles are chelate, at least there is a distinct jaw or curved spine-like process. * * * The body is covered with bristles or feathered hairs, according to the species. The palpi are five jointed, quite prominent, often swollen in the middle, the penultimate joint ending in one or two claws, the last joint (often clavate) appearing as an appendage or "thumb" to the preceding joint. The legs are seven jointed. The tarsi terminate in two small claws. The legs are clothed in the same manner as the body. There are two eyes upon each side of the cephalothorax, quite frequently borne on a distinct pedicel. The genital aperture is situate between the hind coxæ. The anal opening is smaller than the genital and placed a little behind it.

ing more severe annoyance than adults, and young women as a rule suffer more than older persons. People with thin, delicate skin and florid complexion are most afflicted by the mites, and with them the congested red spots are proportionately larger and more inflamed and irritating.

Many persons, however, as, for example, permanent residents of infested regions, and particularly farm laborers, seem to be practically proof against the toxic effects of harvest mites and go with impunity into places overrun with them. This immunity to poisoning is obviously due to two causes: (1) To outdoor work which toughens the person's skin, especially such portions of the arms and legs as are much exposed to the sun and weather; and (2) to inoculation, due to frequent infection.

The inflamed spots due to the presence of the mites under the human cuticle are often diagnosed as hives, nettle-rash, urticaria, or the "weals," and resemble closely those produced on many persons by the "bites" of fleas and some mosquitoes, but on the second or third day each of the mite-infested areas is usually found surmounted at the middle by a minute vesicle or water blister. This is obviously the most important characteristic of harvest-mite attack. After the subsiding of the inflammation and itching, which takes place in a few days, a small scale or scab frequently forms, leaving on some persons a scar which does not wholly disappear in extreme cases for weeks. The mites naturally attack first those portions of the body which are most exposed—those nearest the ground. They

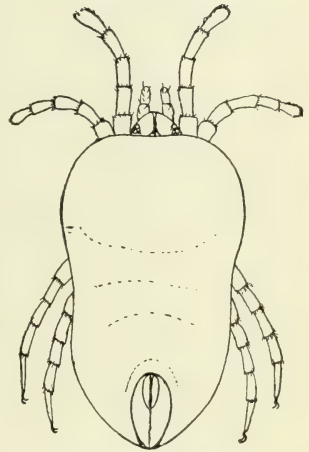


FIG. 3.—*Trombidium*: Adult, highly magnified (from Banks).

crawl into the stockings and penetrate the skin about the ankles, frequently below the shoe tops, and are usually found most numerous below the knee. According to the late Dr. John Hamilton, a physician as well as entomologist, the harvest mites enter the larger sweat tubes or pores of the skin, and as these tubes are very tortuous, the progress of the mites is necessarily slow, from eighteen to thirty-six hours being required for them to reach the end. When the lesions caused by these mites are unusually numerous, the sufferer becomes feverish, and sleep is much disturbed. Sometimes the afflicted one becomes frantic and lacerates his flesh by too vigorous and frequent scratching. Erysipelas is known to follow severe attacks, and death resulting from blood poisoning is recorded. These more serious results of infestation are, however, exceptional and, as with the fatalities which in rare cases follow the ordinarily merely painful or annoying "bites" of many insects, undoubtedly point to an impurity of the blood.

HABITAT.

Harvest mites are most abundant in damp locations, along the borders of streams and other bodies of water, and on the edges of forest and woodland. They occur also on trees and shrubbery, evidently affecting the lower surface of the leaves, from which they drop off when these are rudely shaken, and find lodgment on the neck or other exposed parts of the body. Riley describes "*Leptus americanus*" as affecting chiefly the scalp and armpits. In places infested by harvest mites it is a matter of danger to sit down or lie in the grass and herbage for any length of time, as the mites will then have easy access to almost any portion of the body. As a rule these creatures appear to be dependent on the shade and not to live in the direct sunlight, but some forms occur in sunny locations.

These mites are most abundant and troublesome in the tropics, and become less numerous as we go northward. They are generally distributed in the Gulf States, up the Mississippi River to Missouri and Illinois, and through the Atlantic Coast States to New Jersey. The writer has personal knowledge of their occurrence in troublesome abundance as far north as Monmouth County, N. J., near the central line of the State, but they appear to be unknown in New England or north of latitude 40° in the East. It is probable that these mites occur northward of Monmouth County, as there is a report of infestation on Long Island.

During the summer of 1906 more complaint than usual was received of harvest mites, evidently due to the extremely warm and humid weather which prevailed over the districts affected by these pests.

A communication was received August 24 from a correspondent at Oregon, Ogle County, Ill., of a plague of chiggers in that vicinity, on the hillsides of the banks of the Rock River, 200 feet high. This locality is west and a little north of Chicago and is evidently the northernmost point of which we have actual knowledge of the occurrence of these mites at the present time.

Harvest mites are well known in England and Scotland under this name and as "gooseberry bugs." On the continent of Europe, also, they are abundant, especially in Belgium and the Netherlands, in parts of Germany, and in France. Indeed, in some of these countries they have at times caused considerable annoyance to the peasantry, whom they have hindered or prevented in the harvesting of certain crops. The mites are troublesome, too, in tropical America, in the West Indies, and in Japan.

LIFE HISTORY.

The life history of a harvest mite, as related by Mr. Banks, is substantially as follows: The female lays her eggs in or upon the ground, sometimes to the number of 400 in one place. The eggs are usually

brown and spherical and have been considered by some early writers as fungi. The chorion or outer skin splits soon after the eggs are deposited, dividing the eggs into halves and exposing the pale vitelline membrane. The larva when hatched is circular or ovoid in outline, and each of its three pairs of legs is tipped with two or three prominent claws. After the larva has become attached to its insect host it elongates and becomes swollen with food. When full fed it drops off, seeks a convenient shelter, and gradually changes in shape without molting. The new parts are formed under the larval skin, which after a few weeks cracks and discloses the adult Trombidium. The mature harvest mite is predaceous, wandering about and feeding on aphides, small caterpillars, and, in the case of one species, on the eggs of grasshoppers or locusts. It hibernates in the soil or in other sheltered locations and in the spring deposits its eggs. There appears to be a single generation produced each year. Only a few forms have been reared. The larva of one occurs commonly on the house fly in autumn.

REMEDIES.

Preventive.—As harvest-mite infestation is usually contracted by walking or working among blackberry and other shrubbery which harbors them, or by walking, sitting, or lying among grasses or similar herbage along streams or pools on the edges of marshes or under trees near such places, it is obvious that the best means of prevention is the avoidance of exposure by susceptible persons. If, however, a bath is taken in hot water, or water containing salt or strong soap, within a few hours after exposure, no ill effects will be experienced. After a longer exposure a bath has practically no effect, and direct remedies are necessary.

Sulphur is a sovereign remedy for mites and is the best preventive of attack. When exposure is unavoidable and where vegetation is not more than 2 or 3 feet high, a sure preventive is found in sifting flowers of sulphur into the underclothes from a little above the knee downward and into the shoes and stockings, or it may be rubbed over legs and ankles. Naphthaline has been successfully used in the same manner in Mexico by Dr. L. O. Howard and in Cuba by Mr. E. A. Schwarz. While the sulphur, being inodorous and perfectly effective, is undoubtedly preferable against harvest mites alone, naphthaline is a safeguard against various forms of man-infesting tropical insect pests. Vaseline, pure or mixed with sulphur, will serve the same purpose, but is not so agreeable on account of its oily nature and the certainty of its soiling the clothing.

For most localities these precautions are to be observed through the months of July, August, and a part of September. The mites are seldom bothersome in early June or as late as October, but in exceptionally warm seasons they are apt to be encountered in both months.

Topical applications.—If exposure has been unwittingly incurred or precautions have been neglected and the characteristic irritation has set in, warning the patient of trouble to come, a counterirritant or cooling lotion should be applied directly to the affected parts. For this purpose moderately strong ammonia, applied when the symptoms are first manifest, has offered the best results, and the writer recommends it above all other direct remedies. Bicarbonate of soda or common cooking-soda or saleratus may be substituted in supersaturated solution. Similar alkaline solutions would probably also serve in counteracting the insect poison, which is acid. These substances should be applied liberally until the irritation subsides. Some persons have testified to the value of a 10-per-cent dilution of carbolic acid. Alcohol, camphor, essence of peppermint, and similar preparations are very "cooling," but afford, as a rule, only temporary relief. A dilute tincture of iodine or colloidion applied lightly to the affected parts is a good remedy in case of severe suffering. The latter acts by protecting the "sore" spots from the air.

Destruction of the mites in the field.—Much complaint has been made of the presence of harvest mites on lawns and in vegetation in country grounds and along pathways and roadsides, and information has been solicited by many, including officers of country clubs and the like, for methods of eliminating the mites from such locations. This can be accomplished by keeping the grass, weeds, and useless herbage mowed as closely as feasible, so as to expose the mites to the sun. In some cases this can be facilitated by dusting the grass and other plants, after cutting, with flowers of sulphur or by spraying with dilute kerosene emulsion in which sulphur has been mixed. Grasses on the borders of ponds frequented by cattle, wild blackberry bushes, and similar plants should also be cut down and destroyed in the vicinity of houses and where children and older persons are liable to mite infestation by passing through them. Well-cultivated fields kept free from weeds are not infested with "chiggers," and in the course of time, perhaps a year or two, the measures prescribed, if carefully carried out in grassy locations, should also entirely free these from the pests.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *September 29, 1906.*

CIRCULAR NO. 78.

United States Department of Agriculture,
BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE SLENDER SEED-CORN GROUND-BEETLE.

(Clivina impressifrons Lec.)

By F. M. WEBSTER,

In Charge of Cereal and Forage-Plant Insect Investigations.

The subject of this circular is a small, hard-bodied beetle, belonging to the tribe Scaritini of the family Carabidæ or ground beetles. The former name is derived from a word which means literally "a scratcher," and these beetles have been so designated on account of their widened, flattened, and toothed fore legs, adapting them for digging. They are generally believed to be both carnivorous and predaceous. About 220 species of the genus have been described, principally from the tropics; of these some 22 inhabit America north of Mexico, while 18 of these 22 are known to occur in Louisiana and Texas. *Clivina planicollis* Lec., one of this number, is known also from Mexico, and *C. impressifrons*, here discust, extends its range northward to Nebraska, northern Illinois, Michigan, and New York.

FIG. 1.—*Clivina impressifrons*: Adult or beetle. Enlarged (original).

DESCRIPTION OF THE INSECT.

The fully matured beetle is entirely of a reddish color and about one-fourth of an inch long (6.5 mm.), the shape of the body being as shown in figure 1. It may be recognized by the aid of the following brief technical description:

The lateral margin of the thorax attains the basal margin, middle tibiae with a spur on the outer side near the tip; anterior femora not dentate, thickened; paronychium elongated; vertex sulcate, head smooth, punctured behind, vertical groove deep and long.

Its earlier stages are as yet unknown, altho the larvæ must certainly be very abundant somewhere. We know nothing of its breeding habits, as it is the fully developed insect that does the injury.

INFESTS LOW-LYING, FLAT LANDS.

This beetle appears to depredate only in the lower, flatter lands, and the writer has in past years many times observed it in great numbers floating about on the surface of the water, in cornfields, on the level

prairie country of Illinois, immediately after a severe rain storm in spring. It is in such localities that wireworms are most injurious, and it seems quite probable that a considerable part of the damage placed to the credit of the latter may be really due to this pest. Farmers are often unable to account for their failure to get the seed corn to germinate, and not discovering the cause, they charge it up to wireworms. The writer knows no reason for the beetle's apparent partiality for the lower and usually darker lands and can only surmise that it must find a greater or more easily accessible food supply in such localities, altho probably it is very often carried there in great numbers by the water. The same characteristic is to be observed in many other insects to which this drift theory will hardly apply, hence the reason for this preference must for the present remain obscure. Despite abundance, its depredations do not seem to come to common notice except at long intervals and in widely separated localities, but this again may be due to the fact that the farmer attributes the injuries to other causes, and the entomologist is misled on account of its supposed carnivorous and predaceous habits, which would place it among beneficial instead of injurious insects.

HISTORY OF ITS DEPREDATIONS.

The first record of its seed-corn-destroying habit was published by the writer in November, 1890,¹ the beetles having been received under date of June 11, previous, from Whitley County, Ind., where they were reported as attacking the seed kernels, in the vicinity of the germ, as soon as these kernels had become softened by the action of the moisture in the soil. When this material was received one of the beetles was engaged in burrowing into a kernel after this manner. This instance for fifteen years remained the sole proof of the destructive habits of this insect, in the cornfields or elsewhere.

In 1905 Prof. R. H. Pettit, of the Michigan Agricultural College, reported it as having been received about June 5 of that year, with the complaint of its having worked serious injuries.² In this instance it had operated about Trenton, Mich., where the insects fed upon the seed kernels as previously observed by the writer, and they were found working in a large proportion of the hills soon after planting.

DEPREDATIONS IN THE SPRING OF 1906.

During the spring of 1906 the depredations of this little pest appear to have been unusually severe and more widespread in their distribution over the country. Aside from the cases where the destruction was definitely and unmistakably traced to this insect, there were hundreds

¹ Insect Life, Vol. III, p. 159.

² Bul. 223, Mich. State Agric. Coll. Exp. Sta., p. 50, figs. 51, 52.

of instances where the seed corn failed to germinate, and the owners of these fields could offer no explanation therefor. They knew only that they were obliged to replant much of their corn, and in many cases the replanting failed as did the first. In such cases as these last it is, of course, impossible to fasten the responsibility for the destruction upon this insect, but all such fields as were examined by the writer—unfortunately too late to observe the depredator—were precisely such as we would look for in searching for the work of this insect, that is to say, they were low-lying, flat, very moist, with soil of a darker color and of a more mellow nature. Besides, there was absolutely nothing to show



FIG. 2.—Field of corn near New Paris, Ohio, which had been devastated by *Olivina impressifrons*. Photograph taken after plants had attained considerable size (original).

that there had been any other injury except to the seed kernels, whereas, had the injury been due to wireworms, some, at least, of the growing plants would still have shown evidences of their work. Fields of this description, including one owned by the writer, were observed during the latter half of June, from western Pennsylvania to eastern Kansas, and many others were reported to him but not visited.

There is another beetle, *Agonoderus pallipes* Fab., of a dull yellowish color with central portion of wing-covers black, which has this seed-corn-destroying habit, and it is quite possible that some of all this destruction might have been due to its work, tho this last one is common everywhere and by no means confined to lower lands; neither has it been observed to congregate in such situations.

AN OUTBREAK IN OHIO.

The ravages of the *Clivina* were noticed in several fields of newly planted corn near New Paris, Ohio, during the first week of June, 1906, and one of the writer's assistants, Mr. W. J. Phillips, whose headquarters were at that time at Richmond, Ind., visited the locality on the 14th of the same month and reported on one of these fields as follows:

At the time of my visit the field had been replanted, and the beetles were working in the replants. I counted five beetles in one kernel and as many as twenty around one hill. They enter the kernel from the germ side and seem to eat the entire mass excepting the hull. They do not seem to trouble the corn if it has sprouted and gotten a start to growing.

The whole field contained about 40 acres, but only 10 to 15 acres were injured, and the condition of this portion of the field is shown by the accompanying photograph (see fig. 2). This was the lowest part of the field and in a rich, black soil. The portion of the field that did not seem to be troubled at all was higher up with more of a clay soil. The field is strictly bottom land and nearly always moist.

I took quite a number of the beetles and placed them in a jar of earth and put some corn in the jar. They have tunneled all thru this soil, and (August 7) I still see them occasionally.

Under date of August 29 Mr. Phillips reports a situation in the field as follows:

I have made a number of pilgrimages into Ohio for *C. impressifrons* and could not find any. Yesterday I made another trip. I planted more corn the time before while there. Yesterday I found quite a number of adult beetles, but no larvæ or pupæ. Adult beetles were feeding on the corn. I never find the beetles above ground, but found them as far as 8 inches below ground.

OUTBREAKS IN KANSAS.

Prof. E. A. Popenoe, of Manhattan, Kans., called the writer's attention to two reports of serious ravages that he had received from the southeastern part of his State, both accompanied by specimens of the depredators, but before this information was received from him the attention of the writer had been called to some fields about Lawrence, same State, where farmers had found it impossible to get corn to germinate. These fields were all of them low and swampy, and while in some the crop had been an almost total loss, there was nothing in the fields at that time upon which to convict the depredator except the similarity to other fields known to have been ravaged by this pest. The owners assured the writer that they knew nothing of the cause, only that corn simply would not come up on this ground this year, where before they had not experienced any such trouble.

PREVENTIVE OR REMEDIAL MEASURES.

Remedial measures, that is, such as will stop these depredations in the midst of the insect's work, hardly seem practicable. As to preventives, there has been too little opportunity to observe and experiment. That

the beetle will depredate on underdrained lands seems probable, tho perhaps not so severely except during wet seasons. So far as information has been obtainable, hilled or check-rowed has suffered more than drilled corn; but this point needs to be substantiated by more and exact information based upon field observations. Clearly there is no help to be anticipated from late planting. As the beetle does not attack the seed after it has sprouted, shallow planting in cold, backward seasons would in a measure ward off injuries, because the kernels would sprout sooner than if planted deeply.

Professor Pettit has suggested¹ that if seed be soaked and then rolled in dry slaked lime or plaster mixt with Paris green or some similar poison it would render the seed so treated immune. The trouble here is that seed thus treated could not be planted with the ordinary planters, but would have to be planted by hand. This would, of course, prevent its being applied at the time of the first planting, and thus offer no protection at the time when it is most needed. The seed used in replanting might be so treated, as this work is ordinarily done either with the hoe or a small hand planter.

Experiment has shown that while soaking for a few hours in kerosene may render the seed distasteful, this treatment is likely to be as uncertain in its effects as is petroleum used as an insecticide in the orchard; therefore its use in this case is not recommended. It is to be hoped that farmers and others will promptly report any such outbreaks of this insect as have been observed the present year, and that entomologists will by this means be afforded a better opportunity to investigate and recommend repressive measures that can be applied in the fields by the farmers themselves.

¹ Loc. cit.

Approved:

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *October 4, 1906.*

United States Department of Agriculture, BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE BROOD DISEASES OF BEES.

By E. F. PHILLIPS, Ph. D.,
Apicultural Expert.

In view of the widespread distribution of infectious brood diseases among bees in the United States, it is desirable that all bee keepers learn to distinguish the diseases when they appear. It frequently happens that an apiary becomes badly infected before the owner realizes that any disease is present, or it may be that any dead brood which may be noticed in the hives is attributed to chilling. In this way disease gets a start which makes eradication difficult.

There are two recognized forms of disease of the brood, designated as European and American foul brood, which are particularly virulent. In some ways these resemble each other, but there are certain distinguishing characters which make it possible to differentiate the two. Reports are sometimes received that a colony is infected with both diseases at the same time, but this is contrary to the experience of those persons most conversant with these conditions. While it may be possible for a colony to have the infection of both diseases at the same time, it is not by any means the rule, and such cases are probably not authentically reported. Since both diseases are caused by specific bacilli, there is absolutely no ground for the idea held by some bee keepers that chilled or starved brood will turn to one or the other of these diseases. Experience of the best practical observers is also in keeping with this. For a discussion of the causes of these diseases the reader is referred to Technical Series, No. 14, of the Bureau of Entomology, "The Bacteria of the Apiary, with Special Reference to Bee Diseases," by Dr. G. F. White.

AMERICAN FOUL BROOD.

American foul brood (often called simply "foul brood") is distributed thru all parts of the United States, and from the symptoms published in European journals and texts one is led to believe that it is also the prevalent brood disease in Europe. Altho it is found in almost all sections of the United States, there are many localities entirely free from disease of any kind.

The adult bees of an infected colony are usually rather inactive and do little toward cleaning out infected material. When the larvæ are first affected they turn to a light chocolate color, and in the advanced stages of decay they become darker, resembling roasted coffee in color.

Usually the larvæ are attacked at about the time of capping, and most of the cells containing infected larvæ are capped. As decay proceeds these cappings become sunken and perforated, and, as the healthy brood emerges, the comb shows the scattered cells containing larvæ which have died of disease, still capped. The most noticeable characteristic of this infection is the fact that when a small stick is inserted in a larva which has died of the disease, and slowly removed, the broken-down tissues adhere to it and will often stretch out for several inches before breaking. When the larva dries it forms a tightly adhering scale of very dark brown color, which can best be observed when the comb is held so that a bright light strikes the lower side wall. Decaying larvæ which have died of this disease have a very characteristic odor which resembles a poor quality of glue. This disease seldom attacks drone or queen larvæ. It appears to be much more virulent in the western part of the United States than in the East.

EUROPEAN FOUL BROOD.

European foul brood (often called "black brood") is not nearly as widespread in the United States as is American foul brood, but in certain parts of the country it has caused enormous losses. It is steadily on the increase and is constantly being reported from new localities. It is therefore desirable that bee keepers be on the watch for it.

Adult bees in infected colonies are not very active, but do succeed in cleaning out some of the dried scales. This disease attacks larvæ earlier than does American foul brood, and a comparatively small percentage of the diseased brood is ever capped. The diseased larvæ which are capped over have sunken and perforated cappings. The larvæ when first attacked show a small yellow spot on the body near the head and move uneasily in the cell. When death occurs they turn yellow, then brown, and finally almost black. Decaying larvæ which have died of this disease do not usually stretch out in a long thread when a small stick is inserted and slowly removed. Occasionally there is a very slight "ropiness," but this is never very marked. The thoroly dried larvæ form irregular scales which are not strongly adherent to the lower side wall of the cell. There is very little odor from decaying larvæ which have died from this disease, and when an odor is noticeable it is not the "glue-pot" odor of the American foul brood, but more nearly resembles that of soured dead brood. This disease attacks drone and queen larvæ very soon after the colony is infected. It is as a rule much more infectious than American foul brood and spreads more rapidly. On the other hand, it sometimes happens that the disease will disappear of its own accord, a thing which the author never knew to occur in a genuine case of American foul brood. European foul brood is most destructive during the spring and early summer, often almost disappearing in late summer and autumn.

TREATMENT OF INFECTIOUS DISEASES.

The treatment for both American foul brood and European foul brood is practically the same. It is impossible to give minute directions to cover every case, but care and common sense will enable any bee keeper successfully to fight diseases of brood.

Drugs.—Drugs, either to be given directly in food or to be used for fumigating combs, can not be recommended for either of these diseases.

Shaking treatment.—To cure a colony of either form of foul brood it is necessary first to remove from the hive all of the infected material. This is done by shaking the bees into a clean hive on clean frames with small strips of comb foundation, care being taken that infected honey does not drop from the infected combs. The healthy brood in the infected combs may be saved, provided there is enough to make it profitable, by piling up combs from several infected hives on one of the weakest of the diseased colonies. After a week or ten days all the brood which is worth saving will have hatched out, at which time all these combs should be removed and the colony treated. In the case of box hives or skeps the bees may be drummed out into another box or preferably into a hive with movable frames. Box hives are hard to inspect for disease and are a menace to all other bees in the neighborhood in a region where disease is present.

The shaking of the bees from combs should be done at a time when the other bees in the apiary will not rob and thus spread disease, or under cover. This can be done safely in the evening after bees have ceased to fly, preferably during a good honey flow. Great care should be exercised to keep all infected material away from other bees until it can be completely destroyed or the combs rendered into wax. Wax from diseased colonies should be rendered by some means in which high heating is used, and not with a solar wax extractor. The honey from a diseased colony should be diluted to prevent burning and then thoroly sterilized by hard boiling for at least half an hour, if it is to be fed back to the bees. If the hive is again used, it should be very thoroly cleaned, and special care should be taken that no infected honey or comb be left in the hive.

It is frequently necessary to repeat the treatment by shaking the bees onto fresh foundation in new frames after four or five days. The bee keeper or inspector must determine whether this is necessary, but when there is any doubt it is safer to repeat the operation rather than run the risk of reinfection. If repeated, the first new combs should be destroyed. To prevent the bees from deserting the strips of foundation the queen may be caged in the hive or a queen-excluding zinc put at the entrance.

Treatment with bee escape.—The shaking treatment may be modified, so that instead of shaking the bees from the combs the hive is moved

from its stand, and in its place a clean hive with frames and foundation is set. The queen is at once transferred to the new hive, and the field bees fly there when they next return from the field. The infected hive is then placed on top of or close beside the clean hive and a bee escape placed over the entrance of the hive containing disease, so that the younger bees and those which later emerge from the cells may leave the hive but can not return. They therefore join the colony in the new hive.

Fall treatment.—If it is desirable to treat a colony so late in the fall that it would be impossible for the bees to prepare for winter, the treatment may be modified by shaking the bees onto combs with plenty of honey for winter. This will be satisfactory only after brood rearing has entirely ceased. In such cases disease rarely reappears.

In the Western States, where American foul brood is particularly virulent, it is desirable thoroly to disinfect the hive by burning the inside or by chemical means before using it again. This is not always practised in the Eastern States, where the disease is much milder. Some persons recommend boiling the hives or disinfecting them with some reliable disinfectant such as carbolic acid or corrosive sublimate. It is usually not profitable to save frames because of their comparatively small value, but if desired they may be disinfected. Great care should be exercised in cleaning any apparatus. It does not pay to treat very weak colonies. They should either be destroyed at once or several weak ones be united to make one which is strong enough to build up.

Recently some new "cures" have been advocated in the bee journals, particularly for European foul brood, with a view to saving combs from infected colonies. The cautious bee keeper will hardly experiment with such methods, especially when the disease is just starting in his locality or apiary, but will eradicate the disease at once by means already well tried.

In all cases great care should be exercised that the bee keeper may not himself spread the infection by handling healthy colonies before thoroly disinfecting his hands, hive tools, and even smoker. Since it takes but a very small amount of infected material to start disease in a previously healthy colony, it is evident that too much care can not be taken. In no case should honey from unknown sources be used for feeding bees. Care should also be exercised in buying queens, since disease is often transmitted in the candy used in shipping cages. Combs should not be moved from hive to hive in infected apiaries.

"PICKLE BROOD."

There is a diseased condition of the brood called by bee keepers "pickle brood," but practically nothing is known of its cause. It is characterized by a swollen watery appearance of the larva, usually accompanied by black color of the head. The larvæ usually lie on their

backs in the cell, and the head points upward. The color gradually changes from light yellow to brown after the larva dies. There is no ropiness, and the only odor is that of sour decaying matter, not at all like that of American foul brood. In case the larvæ are capped over, the cappings do not become dark, as in the case of the contagious diseases, but they may be punctured. So far no cause can be given for this disease, and whether or not it is contagious is a disputed point. Usually no treatment is necessary beyond feeding during a dearth of honey, but in very rare cases when the majority of larvæ in a comb are dead from this cause the frame should be removed and a clean comb put in its place to make it unnecessary for the bees to clean out so much dead brood.

CHILLED, OVERHEATED, AND STARVED BROOD.

Many different external factors may cause brood to die. Such dead brood is frequently mistaken, by persons unfamiliar with the brood diseases, for one or the other of them. Careful examination will soon determine whether dead brood is the result of disease or merely some outside change. If brood dies from chilling or some other such cause, it is usually soon carried out by the workers, and the trouble disappears. No treatment is necessary. Brood which dies from external causes often produces a strong odor in the colony, but wholly unlike that of American foul brood, merely that of decaying matter. The color of such brood varies, but the characteristic colors of the infectious diseases are usually absent, the ordinary color of dead brood being more nearly gray.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *October 3, 1906.*

CIRCULAR NO. 80.

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE MELON APHIS.

(Aphis gossypii Glov.)

By F. H. CHITTENDEN,

Entomologist in Charge of Breeding Experiments.

NATURE OF ATTACK.

The melon aphid, or, as it is commonly known, the "melon louse," injures plants by piercing them with its beak and sapping their vitality. It occurs from early spring to late in autumn on melons and other cucurbits of all kinds, and on many other crop plants, and in seasons which favor its increase, notably in summers following springs that are cool and rainy, it frequently develops in enormous numbers and does very serious damage, collecting in masses on the under surface of the leaves of plants and causing them to curl, shrivel, and lose color, and interfering with the ultimate development of the fruit. Often it kills plants outright, and destroys whole fields or greatly reduces the yield of fruit. An affected cantaloupe plant is illustrated by figure 1.

The melon aphid, like others of its kind, excretes "honey dew," but this is not so copious as in the case of many species of aphides, for example, certain forms which affect trees. When, however, the aphid under discussion becomes unusually abundant, the honey dew covers the leaves of the affected plants with a thin, sticky coating on which the white cast skins of the aphides adhere, and this attracts attention to injury, as does also the wilting and dying down of the plants. Some persons notice this honey dew, and are unaware of the presence of the insects. They speak of the injury as "honey dew," and have even applied this name to the insect itself.^a

Quite too frequently, by the time the presence of the melon aphid in injurious numbers is noticed, irreparable damage has been accomplished and the insects have for the most part migrated to other pastures.

^a Attack by many forms of aphides, especially those which excrete honey dew more copiously, can be readily detected by the presence of insects which feed on the sweet excretion. Among these are flies, wasps, bees, and especially ants. The melon aphid, however, is not an especial favorite with ants, altho some common species are occasionally found in attendance upon it. The pavement ant (*Tetramorium caespitum* L.) is the only species which has thus far been observed by the writer, and neither ant nor aphid appears to be in any way dependent on the other for its existence, contrary to that which is the case with many other aphides, particularly those which have root-feeding forms.

DESCRIPTION.

The melon aphid is a minute, soft-bodied creature, of variable color, usually of some shade of green or greenish black; in its young and wingless stages, louselike in appearance; and of sluggish habit throughout its existence. The general appearance of this species in its most commonly observable stages is indicated in figure 2, highly magnified. A brief description of the stages figured will suffice for the present

purpose.

The egg has been described by Mr. Th. Pergande^a as of regularly oval shape and measuring about 0.6^{mm} in length; yellowish or greenish when first deposited, soon changing to jet black.

The larval aphid or nymph (fig. 2, *b*) when first born or hatched presents no observable characters for comparative description. It measures less than 0.5^{mm} and is pale in color, turning later to yellow. The last nymphal stage, corresponding to the pupa of other insects, is sufficiently illustrated at *c* that it requires no verbal description. The apterous or wingless female, which is viviparous (giving birth to living young), is figured at *d*. Great



FIG. 1.—Cantaloupe leaves showing curling caused by melon aphid; aphides on lower surface. Slightly reduced (original).

variation is exhibited in this stage, from pale yellow to very dark green, with black nectaries or honey tubes and pale whitish-yellow legs and antennæ. This stage varies in length from 1.5 to 1.8^{mm} . The winged female is illustrated at *a*, which shows a form with pale abdomen. The body is more slender than in the wingless form, the length being

^a Insect Life, Vol. VII, pp. 309–315, 1895. Technical descriptions are furnished also by Forbes, 12th Rept. St. Ent. Ill. f. 1882 (1883), pp. 83–91.

from 1.2 to 1.8^{mm}, while the wings expand from 4.5 to 6^{mm}. A darker form of the female is shown in profile at *ab*, and the antennæ, much enlarged, at *aa*. The male has not as yet been recognized.

This is by far the most important and abundant aphid affecting melons and other cucurbits, and is not likely to be confused with any other species occurring habitually on the same class of plants.^a It is, indeed, a very important pest, and, taken season after season, the worst aphid occurring in this country.

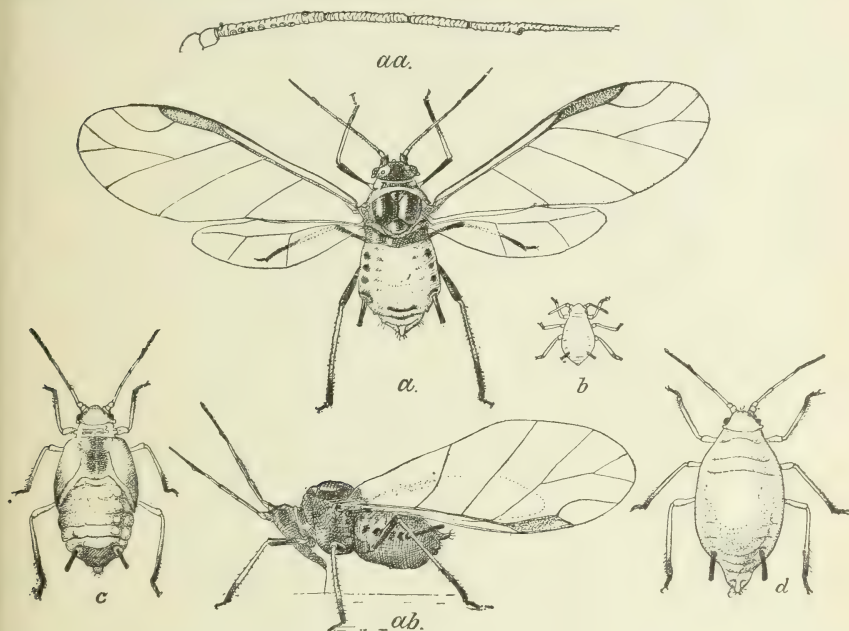


FIG. 2.—Melon aphid (*Aphis gossypii*): *a*, winged female; *aa*, enlarged antenna of same; *ab*, dark female, side view, sucking juice from surface of leaf; *b*, young nymph or larva; *c*, last stage of nymph; *d*, wingless female. All greatly enlarged (author's illustration).

DISTRIBUTION.

The origin of the melon aphid is doubtful, but is probably tropical, since this insect shows a decided preference for plants of a tropical nature, such as the cucurbits, cotton, and orange. Southward the aphid occurs in the West Indies, in Mexico, and in Brazil, and doubtless elsewhere in South America. It is very generally distributed thruout the United States, but does more injury in the southwest than elsewhere. In Texas, Kansas, and Nebraska it is particularly troublesome to melons, and in the last two States to cucumbers, which are there extensively grown for pickling. But it may at any time create

^aThe squash aphid (*Nectarophora* [*Siphonophora*] *cucurbitæ* Middleton), a much larger species, more uniformly green, and of a much lighter and brighter color, is often found on cucurbits, but seldom in sufficient numbers to cause noticeable damage.

more or less trouble in northern regions, particularly in Virginia, Maryland, Delaware, and New Jersey, where cucurbits are much cultivated. Occasionally it is injurious as far north as Minnesota and west to California. It has been collected also in Adelaide, South Australia.

INSTANCES OF INJURY.

The melon aphid first attracted notice thru its injuries to cotton in 1854, and from that time on it has done more or less damage year by year, and, in view of its rapacity, rapid multiplication, and omnivorous habits, will no doubt continue injurious in spite of all that can be done to repress it. As a melon and cucumber pest it was noticed in Florida and southern Illinois in 1880, and in the next three years caused considerable losses in those States and in Georgia. Soon afterwards it became recognized as a strawberry pest. In later years many other food plants were added to its known dietary. The years 1892, 1893, and 1898 were unusually bad "aphid years."

In 1893 information was received from a pickle company of Omaha, Nebr., of severe injury in that State. This company was growing between 30,000 and 50,000 bushels of cucumbers a year, and several hundred neighboring farmers grew this vegetable for the company. Two-thirds of the crop grown in 1892 was destroyed by the aphid, and in 1893 half of the crop was lost. These injuries made it difficult to induce outside planters to grow for the company.

In 1898 this species was extremely troublesome. In order that a good idea of its destructiveness may be had, some reports are cited. In January injury was reported on cucumbers in Florida and in May to strawberries in Delaware, where the insects were described as "taking everything clean." By June this insect had been very injurious to watermelon in southern Texas, when it destroyed many acres of early vines. In July Texas correspondents reported the destruction of 1,000 acres of cantaloupes in one locality, and the outbreak assumed such proportions as to cause much newspaper comment. One company reported that the ravages of this pest had cost them \$20,000, and that agriculturists of that section had sustained irretrievable loss. In November a Pennsylvania correspondent reported losses to cucumbers grown under glass, and in December this aphid resumed its ravages to cucumbers in Florida.

LIST OF FOOD PLANTS.

The insect here considered is the most nearly omnivorous of any known species of aphid. The list of plants upon which it has actually been found feeding shows great diversity, and future observations may add many more host plants.

It is partial to the plants that have previously been mentioned—melons and other cucurbits, cotton, okra, orange and other citrus

fruits, strawberry, and purslane—but it attacks also clover, beans, beets, spinach, tomato, hops, and pear, and several ornamental plants, including hydrangea, begonia, ground ivy (*Nepeta glechoma*), Acalypha, and morning-glory. From its abundance on some of these plants it has received a number of common as well as Latin synonymical names, the former including cotton aphid, orange aphid, cucumber louse, and cantaloupe louse.^a It is frequently called also the “black aphid,” especially in its occurrence in greenhouses. Mr. Pergande has found it feeding upon a large number of weeds, among which are shepherd’s purse, pepper-grass, pigweed (*Amaranthus*), dock (*Rumex*), burdock (*Aretium*), dandelion, lambsquarters (*Chenopodium*), plantain, chickweed, button-weed (*Diodia*), mallow, dogwood (*Cornus*), and Jamestown or jimson weed (*Datura*).

Since these aphides are not at all particular as to their food, when they migrate from their favorite plants they start colonies on nearly any plant that chances to be in their line of flight. The writer has seen asparagus and violet attacked, the latter grown in greenhouses.

LIFE HISTORY.

Attack to cultivated plants begins from early spring till considerably later, and is made by winged individuals flying from weeds which serve as alternate food plants. Infestation naturally commences earlier in the South than northward, and may be simultaneous with the appearance of the crop above ground. Soon after the plants have developed leaves a few winged aphides can usually be found, and these are the forerunners of myriads to follow. As often as a plant becomes exhausted of its vital juices by the sucking mouth-parts of innumerable aphides, winged individuals are developed which migrate to other plants, so that migration in the case of this species is carried on practically thruout the season. Flight from one kind of food plant to another, or from one field to another, is caused also by disturbance from the abundant natural enemies of the insect. The great numbers of this species sometimes suddenly discovered on melons, cotton, orange, and other plants are often due to enforced migration on account of the death of other food plants in the vicinity, such as might be caused by atmospheric conditions, or by the ravages of the aphides themselves, or of other insects. The removal of the crop on which the insect was at work will produce the same effect.

NATURAL ENEMIES.

There is perhaps no better example, among insects, of a common and widespread species being held in abeyance and limited to innoxious

^a The synonyms include *Aphis* (*Siphonophora*) *citrifolii* Ashm., *Aphis citrulli* Ashm., *Aphis cucumeris* Forbes, *Aphis forbesi* Weed. It is still mentioned in literature as *A. cucumeris*.

numbers (save in exceptional seasons) by natural enemies than the melon aphid. The usefulness of these natural enemies, of which a large number have been recorded, in subduing the aphides can not be overestimated. Garden and field aphides generally are subject to attack by the same classes of parasitic and predaceous enemies. The number of species of insects known to prey upon the melon aphid is about 35. The list includes many ladybirds or "ladybugs" (Coccinellidæ),^a which destroy the aphid both as beetles and as larvæ; the maggots of certain syrphus-flies (Syrphidæ),^b which consume large numbers of aphides; aphid lions—the larvæ of lace-wing flies, of the families Chrysopidæ and Hemerobiidæ.^c A number of species of parasitic insects, chiefly minute forms of Braconidæ, are also very important checks on the increase of aphides.^d Many, too, are destroyed by parasitic fungi.

The insect enemies of these, as of other aphides, keep their hosts, in many portions of the country and in ordinary seasons, in nearly complete subjection. The parasites, in particular, are most effective in dry, warm weather. In cooler, moist summer weather, especially following *the same atmospheric conditions in spring*, when vegetables subject to aphid injury are starting growth, these otherwise natural checks are less active, and the aphides, as a result, frequently gain the ascendancy.

Some of the commonest species of ladybird enemies of this and other aphides are illustrated in figure 3. In the "aphid year" of 1898 the *Scymnus* (fig. 3, *h, i, j*) was particularly abundant in and near the District of Columbia on aphid-affected plants. A still more abundant and useful form of this class of insects is the convergent ladybird (*Hippodamia convergens* Guér.), shown in fig. 3, *a, b, c*. It is fre-

^a *Hippodamia convergens* Guér. and *Cycloneda sanguinea* L. are prominent enemies, as are also *Megilla maculata* De G. (fig. 3, *d, e*) and *Coccinella 9-notata* Hbst. Other species are *Scymnus terminatus* Say, *S. caudalis* Lec., *S. cervicalis* Muls. (A), *Chilocorus bivulnerus* Muls., *Erochomus constrictatus* Muls. (H), and *Hippodamia 13-punctata* L.

^b Syrphus flies include *Syrphus americanus* Wied., *Allograpta obliqua* Say, *Baccha clarata* Fab. (*babista* Walk.), *B. lugens* Loew. (H), *B. cognata* Loew. (H), *B. fuscipennis* Say (A), and *Eupeodes volucris* O. S. An agromyzid fly, *Leucopis nigricornis* Egger, also preys on this aphid. Cecidomyiid enemies include certain undetermined species of *Contarinia* (*Diplosis*).

^c Among the lace-wing flies are *Chrysopa oculata* Say, *C. plorabunda* Fitch, *C. albicornis* Fitch (A), *C. nigricornis* Burm. (A), *C. lineaticornis* Fitch (A), *C. attenuata* Walk. (A), *Micromus posticus* Walk., and *Hemerobius gossypii* Ashm. (A).

^d Parasitic braconids include *Triclistus testaceipes* Cress., *Lysiphlebus gossypii* Ashm., *L. citraphis* Ashm., *L. cucurbitaphis* Ashm., *L. minutus* Ashm., *Lysiphlebus* sp., and *Pachyneuron* sp. A chalcid fly, *Stenomomesius aphidicola* Ashm., has also been reared.

The species followed by (H) were observed attacking *Aphis gossypii* on orange trees in Florida by H. G. Hubbard, those marked (A) by Wm. H. Ashmead on cotton in Mississippi. The others are mostly well known, and have been observed by various persons, as well as by the writer.

quently mistaken for the parent of the aphides. Another very efficient enemy, the nine-spotted ladybird, is shown in figure 3, *f*, *g*.

One of the most abundant syrphus-fly enemies is illustrated by figure 4.

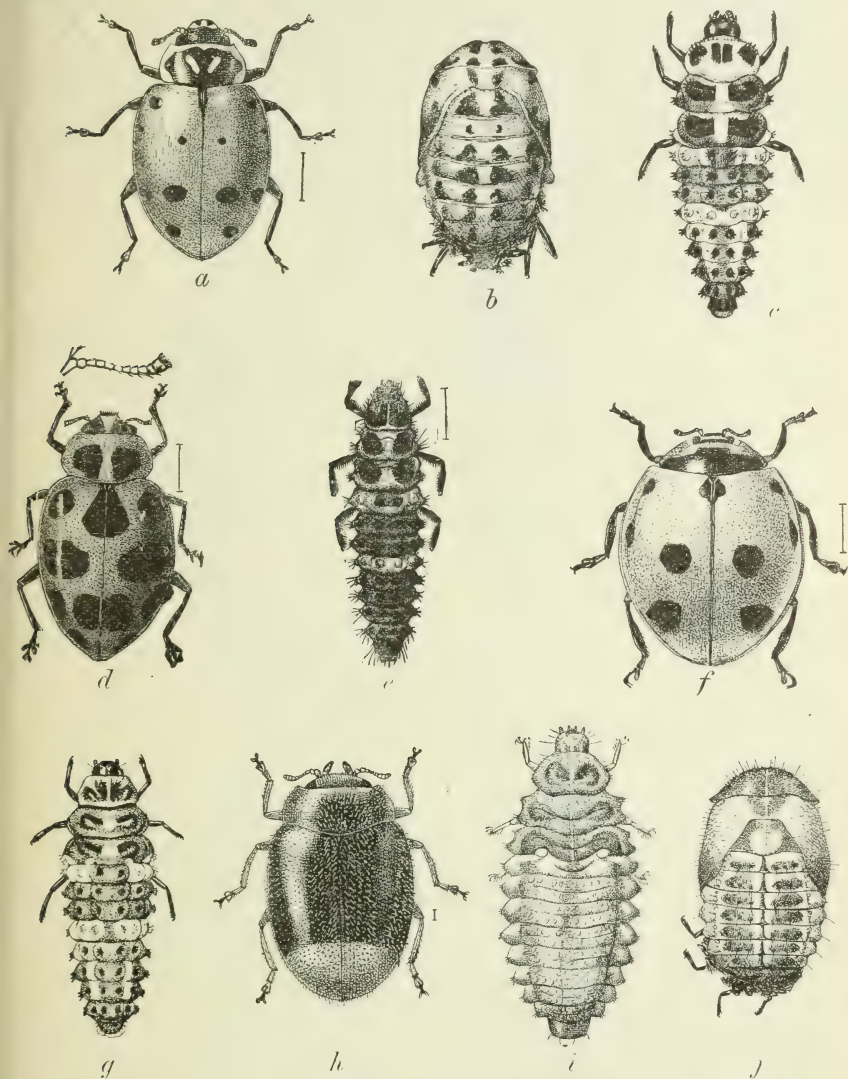


FIG. 3.—a, Adult of convergent ladybird (*Hippodamia convergens*); b, pupa of same; c, larva of same; d, adult of spotted ladybird (*Megilla maculata*); e, larva of same; f, adult of nine-spotted ladybird (*Coccinella 9-notata*); g, larva of same; h, adult of *Scymnus terminatus*; i, larva of same; j, pupa of same. All enlarged; size indicated by hair line at right (author's illustrations, *f-j* original).

Of the natural enemies which have been enumerated, ladybirds are particularly valuable, owing principally to the fact that they are active at all seasons, especially at the outset of aphid attack. Parasites are most effective toward the end of the season, when they often reduce

the aphides so that few are left to hibernate and produce other generations of the pest the following year.

The value of these natural enemies against aphides is such that entomologists frequently advise the employment of remedies only when the enemies are not present in abundance. The possible utilization of natural enemies in the field will be considered on pages 15 and 16 of this circular. In tobacco fumigation, which will presently be considered, we have an almost ideal remedy, for the reason that, while aphides are all destroyed, a considerable proportion of the ladybirds and other hardy beneficial insects, which are practically always present on the infested vines, survive this treatment.

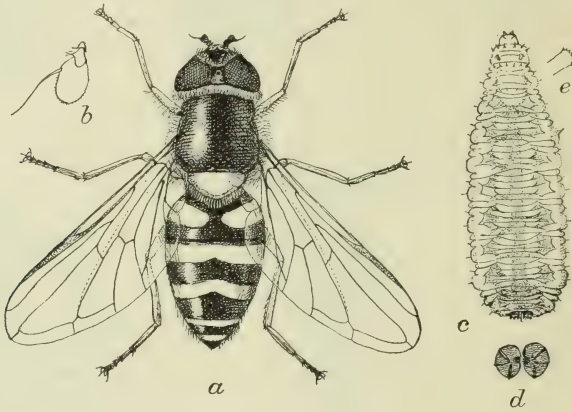


FIG. 4.—A syrphus-fly (*Syrphus ribesii*): a, fly; b, lateral view of head; c, larva or active immature form; d, anal spiracles; e, thoracic spiracle of same. All much enlarged (original).

METHODS OF CONTROL.

The severe losses occasioned by the melon aphid in its seasons of greatest destructiveness could be largely mitigated and in many cases almost entirely prevented if the employment of methods for its control were begun *upon the insect's first appearance*. For its successful treatment it is necessary to keep constantly in mind several of the facts that have already been given more in detail. In ordinary seasons the species is controlled by the combined operation of natural elements and insect enemies, but at times when the weather is unfavorable to the development of these enemies the grower should be on the alert. The presence of the aphides is often not detected until they are numerous, and even then they are not apt to be noticed unless the *lower* surface of the leaves be examined.

All things considered, the most satisfactory way of controlling this insect is by fumigation. As an aid, however, cultural methods are necessary. In the South spraying with kerosene and other emulsions is preferred to the bisulfid of carbon method, and tobacco is now much used, especially in Texas. The encouragement of natural enemies gives promise of success.

BISULFID OF CARBON FUMIGATION.

This treatment of the melon aphid has been used successfully for some time, and is valuable in small fields, but less profitable where cucurbit or other crops are grown over large areas. It consists in evaporating bisulfid of carbon under tubs, or similar tight receptacles, such as pails, buckets, or boxes. The chemical is employed at the rate of a dram (about a teaspoonful) to each cubic foot of space; a tablespoonful will serve for ordinary small tubs. This method of treating the plant does not injure it, and if the tub fit tightly to the ground, so as to retain the vapor of the bisulfid, all of the aphides which are covered will be killed. This method may be followed successfully in large fields if the grower be careful to watch the vines for the first appearance of the insects, and to treat such hills as require fumigation, removing and destroying plants that are badly affected to prevent the spreading of the insects to others.^a

CAUTION.—In the use of bisulfid of carbon as a fumigant for aphides the usual precaution should be observed *not to expose the fumes to fire. The operators must not smoke during this process!* As the gas is heavier than air there is no danger, if ordinary care is observed, that the fumes will be inhaled by human beings.

HYDROCYANIC-ACID GAS TREATMENT.

This gas, as has been demonstrated by Prof. E. D. Sanderson, can be used in the field in much the same manner as the bisulfid of carbon, with wooden tubs or buckets. It has not, however, been adopted by growers and we do not recommend it. It possesses an advantage over bisulfid of carbon in that the cover used in gassing need not fit closely to the earth. On the other hand, it is *decidedly more dangerous to human life and must therefore be handled with the greatest care!*

As a greenhouse insecticide this gas is a perfect remedy for aphides and other small and soft-bodied insects. It is used where tobacco is unsafe; for example, in violet houses, violets being especially subject to "spot" after fumigation with tobacco. The method of applying hydrocyanic-acid gas is described in Circular No. 37 of this Office.

PYRETHRUM POWDER.

Pyrethrum or buhach insect powder, administered dry with a powder bellows to the lower surface of leaves, will kill the insects, altho these sometimes do not appear to be affected at first. A second or third application is sometimes necessary. This is an expensive remedy and can not be used with profit on large fields or on plants with large leaves, like squash.

^a In New Jersey and Colorado many growers simply take out and bury such badly infested plants as are noticed when the hills are turned for cultivation.

FUMIGATION WITH TOBACCO PREPARATIONS.

Tobacco extracts and fumigating powders have been extensively used for a number of years by florists as fumigants against aphides and other insects occurring in greenhouses, such as white fly, thrips, and other small, delicate, and soft-bodied insects. The extracts contain a larger proportion of nicotine than ordinary decoctions prepared by steaming waste stems and powdered tobacco, and are therefore much more effective, which is true also of the powdered forms of nicotine. A number of these preparations are on the market and are advertised in the principal florists' journals and in other agricultural periodicals. They are used in various ways, and directions are furnished with the packages purchased. The liquid preparations vary in strength from 35 or 40 per cent up to 80 to 85 per cent nicotine.

FIELD FUMIGATION WITH TOBACCO.

During the years 1904 to 1906 the employment of tobacco or nicotine preparations in destroying the melon aphid in the field was the subject of experiment in Texas by Messrs C. E. Sanborn and E. D. Sanderson.^a These have stated to the writer that, judging from their experimental use of this method and its practical use by extensive growers, it bids fair to become the best method of dealing with the melon aphid in its occurrence in the South. The process is in brief the fumigation of a dry preparation under a cloth-covered frame placed over the affected vines. In 1905 and 1906 the writer found that a very short exposure to tobacco fumes killed aphides, when other insects, such as thrips, survived a considerably longer treatment.

In practising this method Mr. Sanborn has used apparatus substantially as follows:

Preparation of the frame and cover.—For vines 2 or 3 feet long he advises a light frame 4 by 6 feet, supported by legs 8 inches in length. Lumber three-fourths inch thick and 2 inches wide is suitable. Strengthen the frames by connecting the ends with a crosspiece. Two diagonals are also used for strengthening the frame and for convenience in handling, the latter being attached after the cloth cover is in position. The cover is of muslin of a cheap grade (7 or 8 cents a yard) and sufficiently compact to prevent a passage of gas thru its meshes after being oiled. Its size should be about 2 feet wider and 2 feet longer than the frame which it covers. This is sufficient for an 8-inch wall and a 4-inch lap to the ground. Dirt is placed about the bottom to keep the gas from escaping there.

After the cloth has been cut and sewed into the sizes desired it is saturated in a vessel of linseed oil which fills the pores. It is then

^a An experiment with tobacco smoke as a remedy for this species was made by Dr. S. A. Forbes in 1882. The result was not a perfect success, for the reason that a bee smoker was used and the smoke was blown under canvas hay caps covering the affected plants. Nevertheless from 50 to 75 per cent of the aphides were killed by 10 minutes' exposure.

strung out, slightly dried, and placed over the frame and held in place by nailing the diagonals to the frame above the cloth. A gallon of linseed oil is sufficient for rendering four covers of the size above specified sufficiently air-tight for this method.

The number of frames for use depends upon the degree of infestation and the rapidity of the operators. Ordinarily about 10 frames are sufficient for one man's attention.

Method of application.—The frame is placed over the infested plant. One sheet of the fumigating preparation is torn into from two to four or more equal parts (according to directions on the package or as experience may decide) and each part is put in a tin fruit can under the frame near a corner and then ignited. The cans are perforated at the bottom by driving a large nail in at the side. It is well to use a long taper or fuse for lighting the fumigant, affording the more active beneficial insects time to escape from under the cover before the tobacco fumes are given off. Earth is then heaped on the border of the cloth on the ground to prevent the escape of the smoke. The frame should remain in position ten or fifteen minutes, or longer if preferred. Each operator should have enough frames to handle so that each frame in succession may remain on a vine during the time mentioned.

In localities where the aphid is most injurious local merchants who deal in insecticides should be informed of the fact and requested to keep a supply of fumigating preparation always in stock.

The best time for fumigating is when there is no wind and the vines are damp. In moderately dry weather, however, good results may be obtained.

CAUTION.—Care should be exercised not to allow the dry fumigant to ignite. It should smolder only. Vines should not be disarranged except where they protrude a few inches beneath the cover. The leaves should not touch the top of the cover.

Variations of the fumigating frame.—The frame described above has been used in the fumigation of young plants in southern Texas. The size and make-up of the frames may be altered or improved by the individual grower to adapt them to the size of the vines and the nature of the plant to be fumigated. Farther north than Texas manifestation of injury is not usually observable until the plants have made considerably larger growth, and a larger frame, say about a foot high, will be found more desirable for general use. Unbleached cotton of compact mesh, at 10 cents a yard, answered as well as the oiled "muslin" in experiments conducted by the writer, and there is a saving of time in its use. Moreover, it does not collect dirt nor soil the clothing and other objects with which it comes in contact.

For the treatment of plants other than cucurbits, such as cabbage affected by the cabbage aphid, eggplant, tomatoes, and other truck Mr. Sanborn advises a hood, using a frame made of two wires bent in a semicircle. Strong barrel hoops may be substituted, and the cover tacked to them at the top where they cross and at the bottom of the

hoops. Ornamental plants of low-growing sorts may be fumigated by means of such a hood, while for moderately high plants, such as roses, which are much affected by two common species of aphides, special covers may be constructed.

VAPORIZING AND FUMIGATING TOBACCO IN GREENHOUSES.

In the *vaporization* of tobacco—a practise which has been in use since about 1894 and which has largely superseded ordinary dry-tobacco fumigation in many sections—tobacco stems or dried tobacco, in one or another of its various proprietary forms, are placed in a kettle, metal pail, or similar receptacle. A hose is then connected with a steam pipe, the nozzle inserted in the receptacle, and the house to be treated becomes saturated with the vapor of tobacco, with the resulting destruction of aphides and other soft-bodied insects that may be present, such as thrips or “white fly.”

Liquid preparations are more generally evaporated over alcohol or other lamps, or are placed upon steam pipes, or hot irons are put into the receptacles. For general greenhouse fumigation, fumigating powders are placed in shallow pans, and a few drops of kerosene are added to facilitate ignition. The dry fumigant is designed to burn slowly, so as to produce a smudge which, when dense, is fatal to aphides. This process of treatment may be applied at any time, by day or over night, and upon its completion the house is ventilated. In some cases the plants are syringed, but this is not necessary with plants like cucumbers. A surplus of moisture is to be avoided, owing to the liability of inducing “spot,” mildew, and other fungous diseases on plants susceptible to such maladies.

The amount of a tobacco compound to be used depends upon its strength, the plants to be treated, and the size of the greenhouse. Several forms are for sale under different trade names. It is not probable that these differ greatly from one another in value, but there is much difference in their strength. They are put up in both dry and liquid forms.

In experiments conducted on greenhouse cucumbers at the Massachusetts Agricultural Experiment Station, at Amherst, one of these preparations has been used successfully at the rate of 5 or 6 teaspoonfuls to 1½ pints of water, and vaporized in a space of about 5,000 cubic feet. The length of exposure in this case was over night. Thus used, it does not injure delicate plants, like cucumber, but it kills all aphides and nearly all thrips—for which it was used primarily and which are not infrequently associated with aphides on the plants to be treated.^a

^aThrips and “white fly” (*Aleyrodes* spp.) are more resistant to poisonous gases than are aphides. The former are most effectively destroyed while in the soft immature stages. The adult thrips are hardier and, being winged and more active, spring and fly away, and are thus not so easily brought in direct contact with insecticides like kerosene emulsion. The white flies, on the other hand, are more susceptible to poisons while in the active adult stage. The nymphs are of firmer consistency and comparatively resistant. Remedies for the greenhouse white fly are discusst in Circular No. 57.

Tobacco in fine powder form dusted lightly on very young plants serves both as a repellent and as a mulch, or fertilizer. It is claimed by some to deter the striped cucumber beetle; others report that it is not effective for this beetle.

A successful fumigation or vaporization of a cucumber house infested with the melon aphid was made also in June, 1906, at Anacostia, D. C. A different preparation was used, and 66,000 cubic feet of greenhouse space was fumigated, 22 ounces of the liquid, or 1 ounce to 3,000 cubic feet, being employed. The work was under the writer's direction and conducted by Mr. I. J. Condit, with the cooperation of Mr. J. W. Bryan, owner of the house. At the end of an hour and fifteen minutes, when the ventilators were opened and the greenhouse aired, the aphides were found dead and dying, and the cucumbers were unharmed. Eight evaporators were used in this instance, each holding a little less than 3 ounces of the liquid. It is quite probable that a considerably smaller amount of the preparation, say 1 ounce to 5,000 cubic feet, with an all-night exposure, would have accomplished the same object. The cost of fumigation is not above \$2.50 for a house containing 64,000 cubic feet.

CAUTION.—Before fumigating an entire greenhouse with any substance a preliminary test is always advisable to guard against accidents and to avoid waste of material. In the case of one liquid tobacco fumigant used at Washington, the preliminary test showed that, employed at the strength advised by the manufacturers (*i. e.*, without dilution), it ignited in the evaporating pan instead of vaporizing. This trouble was obviated by diluting the fumigant with half its amount of water, the further precaution being taken of placing a wire gauze beneath the pan and over the flame. In the case of some alcohol lamps used for this purpose the flame is apt to be too strong, especially if placed too near the evaporator. This causes the glass to break. Brass or other metal lamps are therefore preferable. Unless the lamps and wicks are of good quality and fit properly, the alcohol is apt to ooze out around the cork and burn on the sides of the lamp and thus, also, cause breakage.

As a general rule it is best not to fumigate in *bright* sunlight, and not when delicate foliage or flowers have globules of water on them.

SPRAYING METHODS.

Kerosene emulsion and soap solutions.—The melon aphid could be much more readily dealt with if it were not for its unfortunate habit of feeding on the under surface of leaves—which are often badly curled, as shown in figure 1—and for the further fact that in large fields, particularly late in the season when the leaves are large, the vines grow so closely together, frequently becoming interlaced, that spraying by ordinary means is impracticable. Underspraying is an absolute necessity, and a sprayer should be used fitted with an upturned elbow and a

nozzle of the Vermorel type to secure this effect. An elbow designed for this purpose is shown in figure 5.

Kerosene-soap emulsion, the standard remedy for aphides, is the best insecticide for spraying purposes, but various soap solutions are used both for the melon and pea aphides. They are diluted with 6 to 8 parts of water. The emulsion and soap washes are of particular value when the plants are small, as then the aphides can be more readily reached than when the leaves have grown to larger size; and, to repeat, if injuries are to be averted the insect should be checked on its first appearance, not alone on cucumbers, melons, squashes, or whatever the main crop may be, but upon all neighboring plants which may harbor the insect, including beds of strawberry or groves of orange trees.

Kerosene-soap emulsion is prepared by combining 2 gallons of kerosene, one-half pound of whale-oil soap, or 1 quart of soft soap, with 1 gallon of water. The soap is dissolved in boiling water and then poured while still boiling hot (away from the fire) into the kerosene. The mixture is then churned rapidly for about five minutes, pumping the liquid back upon itself by means of a force pump and direct-dis-

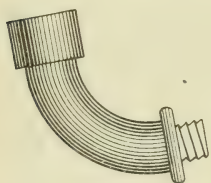


FIG. 5.—Elbow attachment for underspraying. Reduced.

charge nozzle throwing a strong stream. At the end of this time the mixture will have become of the consistency of thick cream. Properly prepared, an emulsion will keep almost indefinitely, and should be diluted only as needed for use. For most species of aphides the staple emulsion should be diluted with from 10 to 20 parts of water. In the preparation of kerosene emulsion a force pump is a necessity, since if not made according to directions a perfect emulsion is not formed. There is then danger of injury to the plants by the kerosene, as also useless waste. There is danger and waste, too, if the insecticide is not applied by means of a fine nozzle in the form of a *spray*, which should be fine and mist-like, or "like a fog," as some one has aptly expressed it. It should be sprayed only for a long enough time to cover the plants, otherwise the liquid forms into globules and runs off. Figure 6 illustrates the method of operating a knapsack sprayer so as to produce an underspraying.

Spraying with water.—Where a few plants only are to be protected, and it is possible to direct a strong stream of water upon them from a garden hose, syringe, or spraying machine, so as to wash off the insects, the aphid can be materially checked without the use of other materials. Such of the insects as come into direct contact with a stiff spray are unable to survive, while others that are dislodged from the plants do not succeed in returning. Many are wingless during the greater part of the season and unable to crawl any distance, particularly if the ground be dry and hot.

Cultural methods give greatest promise as remedies. Clean gardening or farming with fall plowing should always be followed, as these form a most valuable measure of prevention of injury by this and other insects that are present in the fields. As soon as the crop is off the remnants should be gathered and burned. All weeds in the vicinity should be kept down thruout the year, including late fall and early spring, since, as has already been shown, the common weeds of the field and garden are available as alternate food plants and serve as the hibernating quarters of the aphides, which feed more or less thruout the warmer periods of winter. On weeds the insects can be found feeding, in a climate like that of the District of Columbia, until January, "even after heavy frosts or snow," and again in March.

CONTROL OF THE MELON APHIS BY NATURAL ENEMIES.

The possible control of this pest with the assistance of its natural enemies, aided by a trap crop, is proposed by Mr. Sanborn, who has placed at the writer's disposal advance sheets of his publication in which this method is described.

Rape, which is of value for hog and sheep pasture, is the crop advised.

Kale or mustard^a should serve the

same purpose. This method begins in the fall when the trap crop is planted.

The cabbage aphis (*Aphis brassicæ* L.) is closely related to, but quite distinct from, the melon aphis. It winters over on the trap

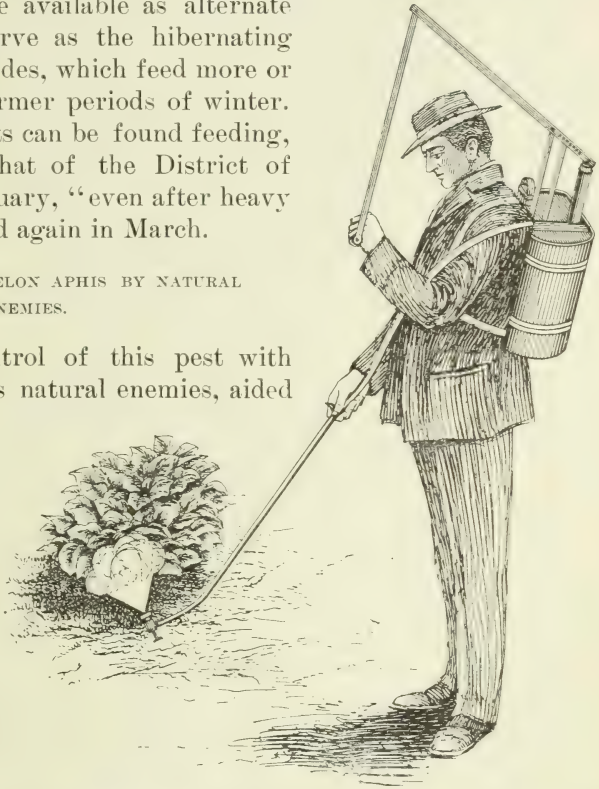


FIG. 6.—Knapsack sprayer in operation, showing method of applying underspray.

^aFor several years the writer has observed that these two crops serve as a trap for the cabbage aphis, by luring them from cabbage and more valuable crops; also, that they are here largely destroyed and practically held in check by their principal insect enemies—which have been illustrated in figure 3; and the idea of employing this means of attracting the natural enemies was suggested to the writer in 1900.

crop and attacks it early in spring, when, unless the natural enemies come to the fore, it multiplies in great abundance. In the writer's experience the ladybirds and other enemies soon gain the ascendancy and become so abundant that they are forced to migrate for food. The trap crop will ordinarily remain in condition to sustain aphides and their enemies until melons or other crops susceptible to melon aphis damage have past the danger stage and are ripening.

The farmer may exercise his own judgment in regard to the location of the trap crop. The writer believes that the greatest advantage would accrue from planting three or more rows of rape or kale on each side and, in the case of fields of more than 4 or 5 acres, by planting additional rows between. Planted on all sides, the trap crop will attract aphides and their enemies from every direction, and this result will be facilitated by permitting the growth of weeds between the rows. In fact, weeds are a desideratum in these operations, since they furnish the best natural hibernating places for the ladybirds and similar beneficial insects. It is advisable also to place boards, loose bark, or hollow logs about the margins of the fields to secure better facilities for hibernation. As fast as one crop of rape, or whatever is used, matures, or its growth is stopt by the aphides (as might sometimes happen), another planting should be made so as to keep a constant supply of cabbage aphides on hand that the natural enemies may not migrate to other quarters.

CONCLUSION.

Many of the remedies that have been indicated as of service in the control of the melon aphis (with the exception of the last) operate against most other cucurbit insects, several species of which are usually present. Thus the kerosene emulsion and soap solutions kill young squash bugs and act as deterrents to most other insects, and bisulfid of carbon will kill other soft-bodied insects besides the aphides, while fall plowing and clean cultural methods are valuable in destroying the squash-vine borer. Tobacco fumigation, however, has little effect on these other insects as they occur in the field.

Approved:

JAMES WILSON,

Secretary of Agriculture,

WASHINGTON, D. C., *November 14, 1906.*

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United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE APHIDES AFFECTING THE APPLE.

By A. L. QUAINANCE,

In Charge of Deciduous-Fruit Insect Investigations.

INTRODUCTION.

Four species of aphides, or "plant-lice," commonly infest the apple in the United States, namely, the woolly apple aphis (*Schizoneura lanigera* Hausm.), the European grain aphis (*Siphocoryne avenæ* Fab.), the apple aphis (*Aphis mali* Fab.), and the rosy apple aphis (*Aphis mali-foliæ* Fitch). The first mentioned—the woolly apple aphis—infests the roots of the apple, producing a knotted, distorted growth, and also the limbs and branches, where the colonies are quite conspicuous from the white, flocculent material which the insects secrete. This species has been treated in Circular No. 20, second series, of this office, to which the reader is referred. The other species above mentioned infest the more tender growing shoots and leaves of the apple, and are especially injurious when occurring on young orchard or nursery trees, which are more commonly infested than older trees, making comparatively little annual growth. Water sprouts also are frequently infested, and the shoots of top-worked trees are especially subject to attack.

The presence of these insects is indicated by the curled and distorted condition of the more terminal leaves, and if a plant showing these symptoms be closely examined, small oval or pear-shaped soft-bodied aphides, greenish or pink in color according to species, will be found on the under surface of the leaves, along the tender stem or elsewhere, often practically covering these parts (see figure 1).

Each aphis is provided with a small beak, which is pushed down into the tissues of the leaf or stem and by means of which the sap is sucked up for food. When the insects are abundant, the drain upon the plant is very great, interfering with its proper growth and development, and in extreme cases causing the death of the infested parts.

The leaves and shoots of plants infested by these insects are frequently seen to be covered with a black substance, as if dusted with

soot. This is due to a black fungus which grows on the "honey dew" excreted by the aphides. This may be produced in such quantities as to coat the leaves, and is attractive to various species of ants and wasps frequently to be seen attending the aphides or frequenting plants infested by them. The black fungus noted is not in itself especially injurious, but it usually indicates the presence of aphides.

which may be the cause of material injury.

APHIDES IN GENERAL.

The insects of the family Aphididæ, or "plant-lice," are especially remarkable on account of their mode of development. This will vary considerably according to the species, but at some time in the life of a species true sexes are produced, usually in the fall, the sexual female depositing eggs after the usual manner of insects. Eggs deposited in the autumn pass the winter in this condition, and their hatching in the spring is more



FIG. 1.—Terminal shoot of apple infested with the apple aphid (*Aphis mali*), showing condition of leaves. (Original.)

or less coincident with the revival of growth of vegetation. From the winter eggs is produced a generation of females, usually wingless, which reproduce agamically—that is, without the intervention of males, many species, as those under consideration, giving birth to living young. The adult aphides of this first generation are termed "stem-mothers." The offspring of the stem-mothers (second gener-

ation) may be winged or wingless, or both forms may occur; they reproduce agamically, some species being oviparous and depositing pseudoova, or eggs which do not require fertilization for development; while others are viviparous and bring forth young alive, the pseudoova developing within the body of the parent. There may be a succession of generations produced agamically, with most species this mode of reproduction continuing until the approach of autumn, when the true sexes appear and deposit eggs; or a species may be more or less biennial, some individuals producing true sexes only every second year. With still other species, the true sexes of which are at present unknown, agamic reproduction possibly continues for a series of years. The same species of aphide may present several forms, as wingless agamic females, winged agamic females, and the true sexual forms; in the last the male may be winged and the female wingless, or both sexes may be wingless. The different generations of a given species may vary more or less, and in some instances this is the case to such an extent that they appear to belong to distinct species. Aphides are enabled to increase with great rapidity by reason of the short time required by their young to reach maturity. Their powers of multiplication are so great that if unchecked the product of a single insect during one season would run up into the billions. Very fortunately, however, there are many drawbacks to their increase, among which are certain weather conditions, parasitic and predaceous insects, and fungous diseases. When one or more of these agencies are in abeyance, aphides may become very numerous and destructive locally or over a considerable range of territory.

THE EUROPEAN GRAIN APHIS.

(*Siphocoryne avenæ* Fab.)

The European grain aphid (fig. 2) is the common greenish apple aphid of the United States, and is the species erroneously considered by Fitch as identical with the European *Aphis mali* Fab., by which name until recently it has been very generally known in our literature. Two species, however, have been confused under this name, the present and the following, which fact was recognized by Mr. Th. Pergande, and also by Dr. J. B. Smith. Prof. E. D. Sanderson in 1902 described this insect as new under the name of *Aphis fitchi*, but Pergande has subsequently shown that the insect is identical with the European grain aphid (*Aphis avenæ* Fab.), and considers that the species really belongs to the genus *Siphocoryne* of Passerini. This species is recorded from various widely separated localities, and is probably very generally distributed throughout the United States. Twenty-two plants upon which it has been observed are recorded, comprising eight trees, four weeds or herbs, and ten grains and grasses. Of orchard fruits, apple, pear, quince, and plum are food-plants; and of grains, rye, oats, and

wheat are infested, the last, according to Prof. F. M. Webster, often being quite seriously injured by the aphides in the fall, the young plants being attacked at or just below the ground.

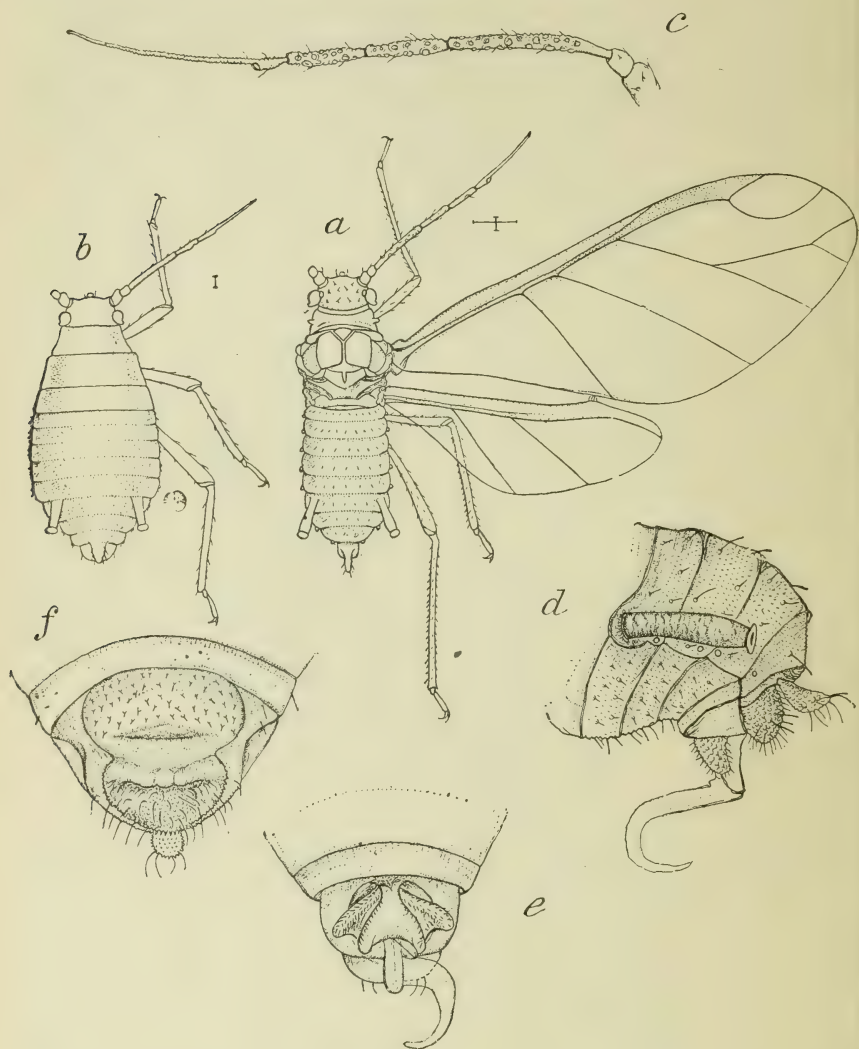


FIG. 2.—The European grain aphid (*Siphocoryne avenae*), a common aphid on apple: a, migratory female; b, sexual female; c, antenna of migratory female; d, side view of end of body of winged male; e, under side of end of body of male; f, under side of end of body of sexual female. All greatly enlarged (from Pergande).

NATURAL HISTORY AND HABITS.

This species has been well treated by Sanderson and Pergande, and has been found to present a very interesting life history. The shiny, jet-black winter eggs are deposited by the females in the fall around the buds of the more terminal shoots, at crotches of limbs, and in cracks

and under scales of the bark. The eggs are quite small, but may be readily detected with the unaided eye. These hatch in spring, about the time the young leaves of the apple are pushing out, and the small, greenish "lice," often occurring in large numbers, at once attack these parts. These insects, when fully grown, are the stem-mothers, and soon begin the production of living young, most of which develop into the winged agamic form which migrates to other trees and to other localities, where new colonies are started, the progeny of the third generation also being winged and wingless. In all, some five generations of aphides develop on the apple, but by early July in the latitude of Washington the trees are free from them, and the aphides have become established on grains and grasses or other host plants. Upon the approach of fall, apple trees are again infested by the return migrants from the grasses and grains, the true females are soon produced, and the winged males come from the grasses upon which they have developed. Winter eggs are deposited during September, October, and early November in the manner indicated.

THE APPLE APHIS.

(*Aphis mali* Fab.)

In general appearance the apple aphis (fig. 4), or apple leaf-aphis, is much like the preceding, with which it has been confused. The body is pear-shaped, instead of oval as in *S. avenæ*, the colors of both being yellowish green, greenish, or darker, varying considerably in detailed markings and in the several generations.

Aphis mali Fab. (*pomi* De Geer) is of European origin, and has only recently made its appearance in this country, Mr. Pergande having first seen specimens collected in the United States in 1897. However, at the present time it is widely distributed, having been recorded from New Jersey, Delaware, New York, Connecticut, Colorado, Michigan, Alabama, and Georgia. The records of this Bureau show it to occur in Kentucky, Louisiana, Oregon, Pennsylvania, Nebraska, and Arkansas. In this country the insect appears to infest apple (fig. 1) principally, if not entirely, though in Europe it infests in addition the wild crab (*Pyrus malus*), pear, and white thorn (*Cratægus oxyacantha*).



FIG. 3.—Eggs of the apple aphis (*Aphis mali*) on twig. (Original.)

NATURAL HISTORY AND HABITS.

The apple aphis has been studied by Dr. J. B. Smith and Prof. E. D. Sanderson. Winter eggs (fig. 3) are deposited by the sexual females

in the fall, oviposition beginning somewhat earlier than but overlapping with that of the preceding species; they are placed in similar situations, and are not distinguishable from those of *Siphocoryne*

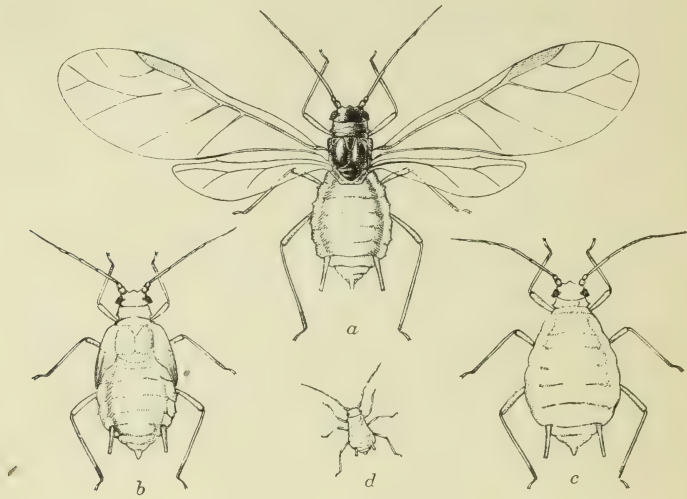


FIG. 4.—Apple aphid (*Aphis mali*): a, winged agamic form; b, pupa; c, wingless agamic form; d, recently born aphid. All greatly enlarged (original).

avenæ. They hatch perhaps somewhat later in the spring, and after the foliage is further advanced and, like the species next considered, the aphides developing from them cause a greater curling of the

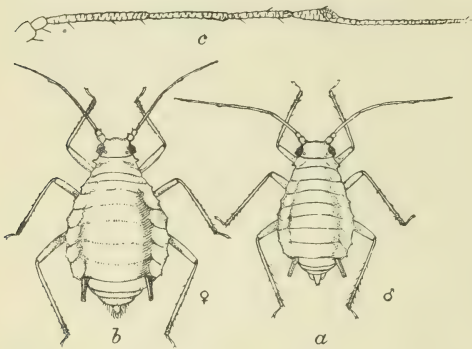


FIG. 5.—Apple aphid (*Aphis mali*): The true sexual forms: a, male; b, female. Greatly enlarged (original).

leaves. The apple leaf-aphid infests the apple throughout the year and for this reason is capable of more injury than the other species herein treated. Upon the hatching of the winter eggs in spring a succession of agamic generations is produced, the earlier ones, except the first, with numerous winged individuals which migrate to other trees and establish new colonies. In New Jersey, as found by Doctor Smith, there may be during the season seven agamic generations followed by the development of the sexual wingless males and females (fig. 5) in the fall.

THE ROSY APPLE APHIS.

(*Aphis malifoliae* Fitch.)

The rosy apple aphis (fig. 6), regarded by Pergande as *Aphis malifoliae* Fitch, and determined by Sanderson as *Aphis sorbi* Kaltenbach, is readily distinguished from the preceding by its larger size, rounder body, and usually rosy color, which, however, may vary from salmon to tan or even to slaty gray or black, the body being covered with a whitish pulverulence. This species is very generally distributed in the United States, occurring in such widely separated States as Illinois, Connecticut, New Jersey, Virginia, Washington, California, South Carolina, and West Virginia; it occurs also in Canada. The species is common on apple, but has been taken by Sanderson on pear.

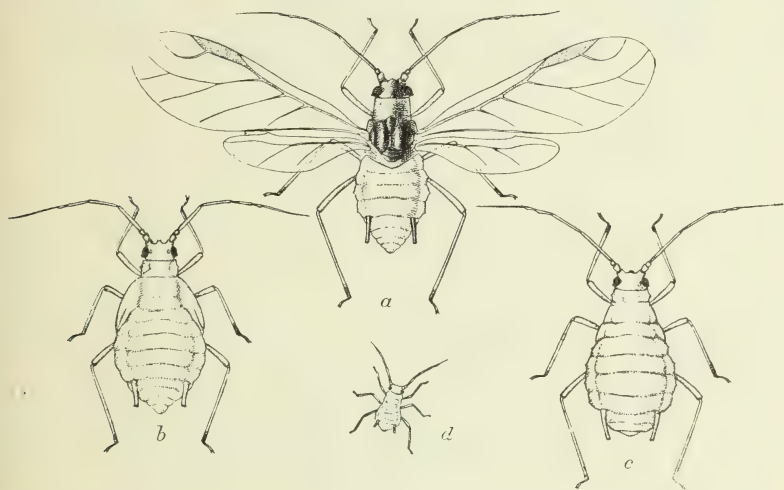


FIG. 6.—Rosy apple aphis (*Aphis malifoliae*): a, winged agamic form; b, pupa; c, wingless agamic form; d, recently born aphid. All greatly enlarged (original).

In Europe the food plants of *Aphis sorbi*, in addition to apple, are *Crataegus oxyacantha*, *Sorbus aucuparia*, *S. domestica*, and *S. torminalis*.

LIFE HISTORY.

The life history of this species is but imperfectly known. Winter eggs are deposited in the autumn by sexual females, and more often on the trunk and larger limbs than with the other species mentioned. They hatch in spring as the apple leaves are pushing out, and the young aphides infest the young leaves and later the tender shoots and foliage, the latter thus becoming usually badly curled. Three generations from the egg are said to occur on the apple in the spring, many individuals of the second and third generations developing wings and migrating to other trees and to other host plants. After the third generation the apple is deserted by the insects until fall, when the return migrants appear and give rise to the true sexual forms, the females depositing eggs as described.

NATURAL ENEMIES OF APHIDES.

Aphides are attacked by various species of predaceous and parasitic enemies, and by fungous diseases, and under certain climatic conditions

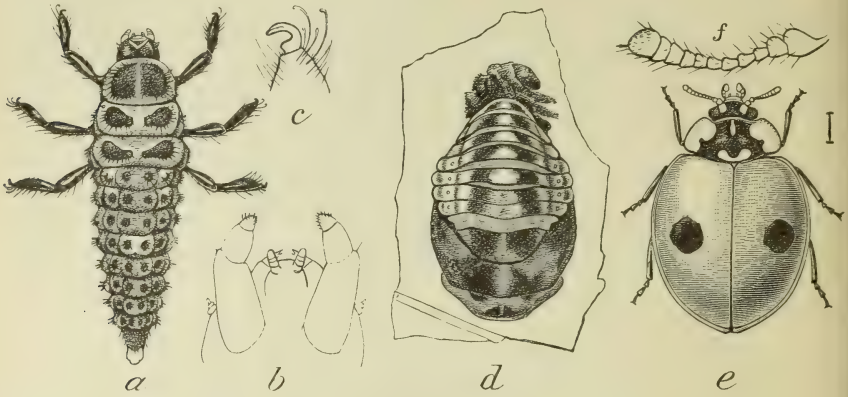


FIG. 7.—Two-spotted ladybird (*Adalia bipunctata*): a, larva; b, mouth parts of same; c, claw of same; d, pupa; e, adult or beetle; f, antenna of same. A common arboreal ladybird. All enlarged (from Marlatt).

these agencies exert a very important influence in their control. Species of ladybirds or Coccinellidæ (fig. 7), aphid lions—the larvæ of Chryso-

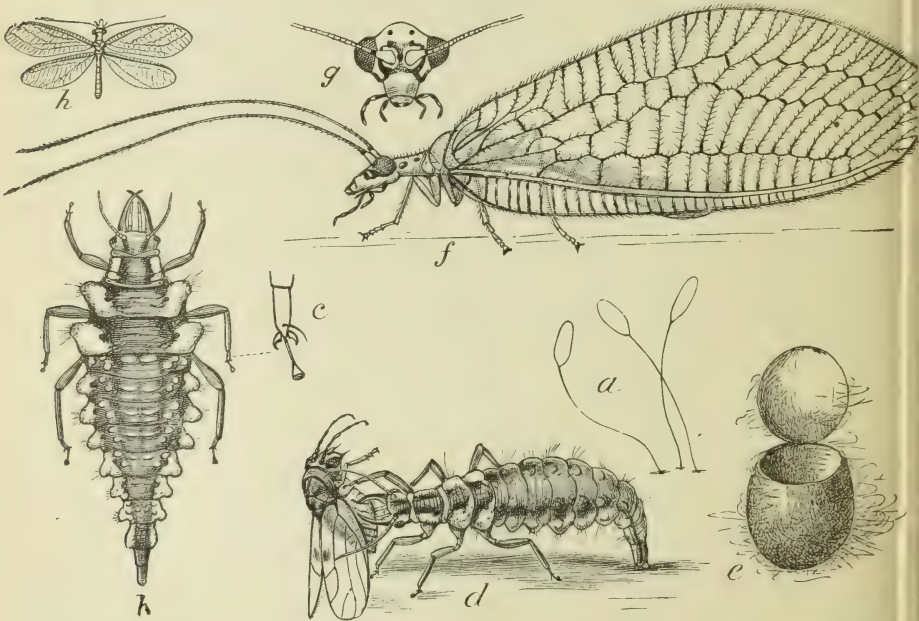


FIG. 8.—The golden-eyed lace-wing fly (*Chrysopa oculata*): a, eggs; b, full-grown larva; c, foot of same; d, larva devouring an insect; e, cocoon; f, adult insect; g, head of same; h, adult, natural size. All enlarged except h (from Marlatt).

pidæ (fig. 8) and Hemerobiidæ—and the larvæ of syrphus flies prey upon the apple aphides, which are destroyed also by small hymenop-

terous parasites. Under certain weather conditions entire colonies may be destroyed by fungous diseases. During periods of rainy weather the insect enemies of aphides are much less active than when the weather is fair. This is particularly true of the minute delicate-winged hymenopterous parasites, to which such weather conditions are largely fatal. With the coming of fair weather, however, these foes of aphides soon multiply, quickly reducing their hosts to much less injurious numbers.

METHODS OF CONTROL.

Pruning.—As has been stated, the aphides under consideration pass the winter in the egg stage on the apple, the eggs being deposited more or less promiscuously over the more nearly terminal twig. With young trees especially, which are seen to be heavily stocked with the eggs, the latter may be largely removed during the work of pruning, and the prunings should be collected and burned.

The insects in the egg condition are frequently distributed on nursery stock; therefore, if in planting trees this stock be well pruned and the prunings destroyed, the establishment of the aphides in young orchards may be often prevented or delayed.

Winter spraying for destruction of eggs.—Several sprays have been at various times more or less used for the destruction of the eggs on the trees; among these are strong lye water, whale-oil soap, and kerosene and crude petroleum—in soap or mechanical emulsions with water or even undiluted. On the whole, very little of practical good seems to have followed these treatments, the eggs being largely resistant to such insecticides as are not so strong as to injure the trees. In the experience of Prof. J. M. Aldrich, however, excellent results have followed the use of lime-sulphur wash, most all of the eggs of the apple aphid having been destroyed by one thorough application in spring shortly before the buds opened. The use of this wash for the eggs of aphides would also control the San Jose scale when present.

Spring and summer treatments.—Effective work in controlling these insects may be done in the spring just after they have hatched from eggs and have collected on the expanding foliage. Trees seen to be badly infested at this time should be thoroughly sprayed, taking pains to wet as completely as possible all parts of the leaves, twigs, and branches. However thoroughly the work may be done, some of the “lice” are almost sure to escape destruction, owing to the difficulty of forcing the spray between the unfolding leaves, more or less covered with hairs, where some of the insects will have penetrated. A subsequent treatment in the course of a week should usually be made, especially if the first application is seen to have been unsatisfactory.

After the foliage is well out and more or less distorted from the presence of the aphides, effective spraying is quite difficult, since

many of the insects on the lower surface of the curled leaves will not be hit by the spray. Repeated applications must be made, therefore, as necessary to keep the insects under control. It will often be found practicable to bend over and immerse the terminal shoots of badly infested young trees in a bucket of the spray solution, and this treatment will be very effective.

Spray mixtures.—The lime-sulphur wash for the destruction of winter eggs is made according to the usual formula for the wash, namely, lime 20 pounds, sulphur 15 pounds, water to make 50 gallons, and boiled for one hour.

After the trees are in foliage, a more dilute contact insecticide must be employed, as strong tobacco decoction, 15 or 20 per cent kerosene emulsion, 15 per cent crude petroleum emulsion, or whale-oil soap at the rate of 1 pound for each 4 gallons of water. Since aphides secure their food by sucking up sap from within the plant, none of the arsenical poisons would be effective.

Tobacco decoction may be made from tobacco stems and other refuse tobacco by boiling at the rate of 1 pound for each 1 or 2 gallons of water, sufficient water being added to make up for that lost in boiling.

A 20 per cent kerosene or crude petroleum emulsion is made as follows:

Whale-oil or other soap.....	pounds..	2½
Kerosene or crude petroleum.....	gallons..	10
Water to make	gallons..	50

The soap is dissolved in 5 gallons of hot water, which is at once poured into the spray-pump barrel. The 10 gallons of kerosene or crude petroleum is next added and the whole thoroughly emulsified by pumping it back through the hose into the barrel for 6 or 8 minutes. After the oil has become thoroughly emulsified, the barrel is filled with water, and the preparation is ready for use. When a less amount of emulsion is desired than the quantity above indicated, it may be reduced as desired by observing the proportions given.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *December 18, 1906.*

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BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

**PINHOLE INJURY TO GIRDLED CYPRESS IN THE SOUTH ATLANTIC
AND GULF STATES.**

By A. D. HOPKINS,

In Charge of Forest Insect Investigations.

Pursuant to certain complaints of serious injury by wood-boring insects to girdled cypress timber in the South Atlantic and Gulf States, the Bureau of Entomology began a series of experiments and investigations with special trees girdled on definite dates in every month of the year, as well as with those girdled in regular operations at known dates or periods, to determine whether or not there was any important relation between the month or time of year the trees were girdled and subsequent injuries.

This work was personally conducted by specialists of the Bureau in cooperation with cypress manufacturers in southeastern North Carolina, southern South Carolina, southeastern Georgia, western Florida, and southern Louisiana. It was begun in the spring of 1903 and continued until December, 1904. Over 300 trees were examined, and observations were made on practically all of the different species of insects which are in any manner associated with injury to the wood and bark of living, dying, and felled, as well as girdled, cypress.

RESULTS OF INVESTIGATIONS.

The principal injury to the wood of standing girdled cypress was found to consist of pinholes in the sapwood and heartwood caused by two classes of small wood-boring beetles, called timber beetles, ambrosia beetles, pin borers, "pin worms," etc. They bore the so-called pinholes in the wood as places to deposit eggs and rear their broods, and the latter, when fully developed, leave the wood and fly to other trees to repeat the process.

One of these classes of wood-boring beetles is represented by small, short, cylindrical, reddish beetles one-eighth to one-tenth of an inch in length, which are exclusively sapwood borers. As a rule they are not common in girdled trees, but are abundant in logs from living trees.

The other class is represented by elongate, slender, reddish, cylindrical beetles three-eighths of an inch in length, which often extend their borings deep into the heartwood and are often common and quite

injurious to both girdled and felled trees. One species of this latter class causes more damage, perhaps, than all of the many other insects which have been found boring in the wood of girdled trees. It is known technically as *Platypus compositus* Say, and may be distinguished from other cypress pin-borers by the English name "girdled-cypress pin-borer," or Pan American Platypus. (See fig. 1.)

The facts and evidence of immediate practical importance may be briefly stated as follows: Trees girdled in March, April, October, and November were not at all or but slightly damaged by the girdled-cypress pin-borer, while those girdled in May, June, July, and September were more or less seriously damaged. There were indications that trees girdled in August were not damaged as badly as those girdled in July

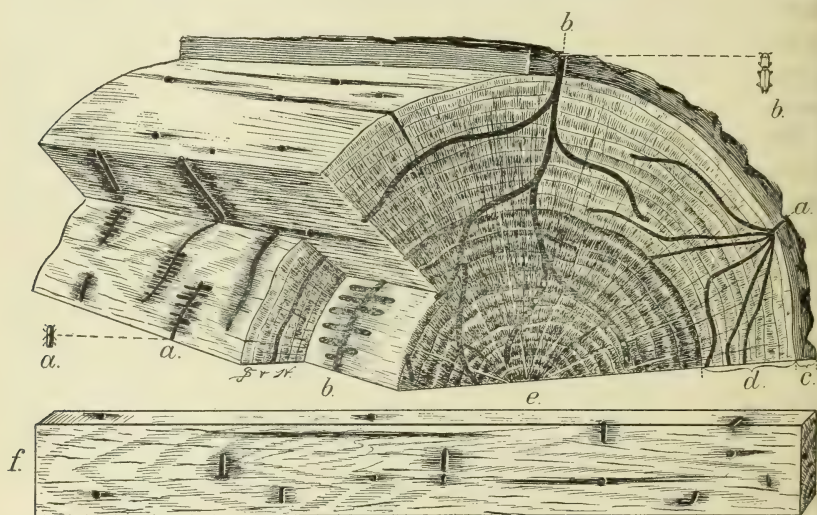


FIG. 1.—Work of ambrosia beetles in oak: a, *Monarthrum mali* and work; b, *Platypus compositus* and work; c, bark; d, sapwood; e, heartwood; f, character of work in lumber from injured log. (Author's illustration.)

and September; also, that trees girdled from December to February were not seriously affected. It was found that local factors and conditions had an important bearing on whether or not injury resulted from girdling at given dates. In some localities there was practically no injury to trees girdled on any of the dates. In other localities some of the trees girdled on a given date would be badly damaged while others would show no trace of injuries. The absence of injuries in the former localities may have been due to the presence of a limited number of the insects, or to their being attracted to felled trees in preference to the standing girdled ones, or to some other unknown causes. The attack on individual trees is evidently due to individual differences in the trees themselves, for our general observations indicate quite clearly that certain types and varieties of trees of the same species are more resistant

or immune to their insect enemies while others are more attractive to them. It is well known that there is a marked difference in the individual characteristics of cypress trees in any given locality, and especially so in different localities, and that there is also marked difference among a large number of trees girdled on the same day or time of year in the results obtained. Some will die quickly and dry out rapidly; some will remain alive a much longer time, the wood remaining moist and becoming discolored; some will yield beautifully grained lumber of the highest grade; while others, equally as sound, will yield tough, cross-grained, dull lumber of a low grade. These conditions are not due entirely to the character of the work of girdling, nor to accident, local influences of soil, etc., but largely to variations which produce more or less distinct, good and poor natural varieties. Therefore certain trees or varieties which prove to be especially attractive to the pin-borer, no matter when they are girdled, may be attacked and more or less injured.

The girdled-cypress pin-borer *must have* moist wood in which to excavate its burrows and develop its broods of young and *will not* attack the trees after they have been dead long enough for the wood to become dry. It evidently prefers to attack the wood of felled gum and cypress. Our observations indicate that living trees felled in April and August offer specially attractive conditions for infestation by this species, and that it will often begin to enter the wood within a few days after the trees are felled. This suggests the utilization of felled trees as traps to attract it away from the girdled ones and at the same time facilitate the destruction of the broods by placing the logs of the trap trees in water after they have become thoroughly infested and before the broods of adults begin to emerge and fly.

To accomplish this the trap trees felled in April must be burned or placed in water during the following June and those felled in August treated in the same manner in October.

RECOMMENDATIONS.

General recommendations for the prevention of insect injury to girdled cypress may be briefly stated as follows:

First.—Conduct the principal girdling operations in March, April, October, and November, or either in the former or latter months as may seem best from the local conditions and relative value of the product in each locality. October-girdled trees should be felled and floated or worked up within one year to avoid injury by another class of wood borers which attack trees after they have been dead one or more years.

Second.—In localities where it is known that the insect is abundant and injurious, felled trap trees may be provided in March and April, and July and August, say, one otherwise worthless gum or cypress trap tree for each fifty to seventy trees to be girdled in the same locality.

Third.—If it is desirable to girdle trees at other times during the summer and to utilize trap trees, these latter should be provided a week or more ahead of the girdling, and located on the banks of streams, ponds, or pools, where, at the proper time, they can be readily rolled into the water.

Fourth.—Trap trees should never be provided unless it is quite certain that they will be placed in the water or otherwise destroyed within two or three months after they are felled and infested by the insects, otherwise they may contribute to a greater multiplication of the insects and increased danger of serious injury to the girdled trees.

The adoption and carrying out of these recommendations should be governed in each locality by the personal observations and experience of the operators, based on a study of the conditions resulting from trees girdled at different positively known dates or times of year, and also on a study of the evidences of infestation by the pin-borer in the girdled trees and in the logs, stumps, slash, etc., of cypress, gum, and other trees. These evidences of infestation consist of the greater or less quantities of fine, whitish boring-dust on the bark and around the base of the trees and stumps, under the logs, etc., the work of the girdled-cypress pin-borer and its class being distinguished from that of the sapwood borers by the prevalence of short cylindrical sections of adhering dust expelled from the holes.

For more detailed information on the habits of wood-boring insects and the character of injuries caused by them in standing and felled trees, lumber, etc., the reader is referred to the Yearbook of the United States Department of Agriculture for 1904, pages 381 to 398.

Approved :

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *December 19, 1906.*

United States Department of Agriculture, BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE LOCUST BORER¹ AND METHODS FOR ITS CONTROL.

By A. D. HOPKINS,

In Charge of Forest Insect Investigations.

The locust borer and its relation to detrimental and destructive injuries to the black or yellow locust² in the eastern United States have been subjects of special investigations by the Bureau of Entomology during the past two years, which have resulted in the determination of practical methods of control.

The locust borer is whitish, elongate, so-called "round headed" grub or arva (fig. 1), which hatches from an egg (fig. 2) deposited by black or brown and yellow striped longhorned winged beetle (fig. 3) found on the trees and on the flowers of golden-rod from August to October. The eggs are deposited in the crevices of the bark of living, growing trees from August to October, and the young borers (fig. 2, *b*, *c*) hatching therefrom excavate individual cells in the outer layers of the inner living

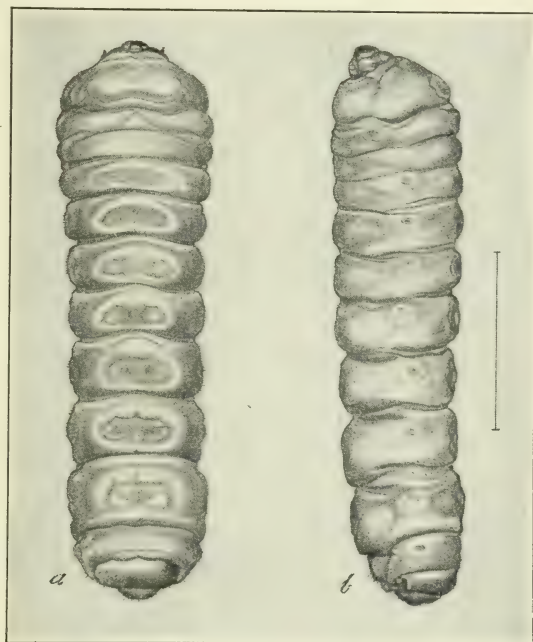


FIG. 1.—The locust borer (*Cyllene robiniae*): *a*, larva, dorsal view; *b*, same, lateral view. Line at right represents natural length (author's illustration). The larva in profile should show minute prothoracic feet.

¹ *Cyllene robiniae* Forst; Order Coleoptera, Family Cerambycidae.

² *Robinia pseudacacia*.

bark (fig. 4), where they pass the winter, and in the spring bore through the bark into the sapwood and heartwood. Here they transform in July and August to pupæ and in August and September to adult beetles, which soon emerge from the trees and deposit eggs for the next annual generation of borers and beetles.

The injury to the trees consists of wounds in the bark and sapwood which, if sufficiently severe or repeated year after year, result in either a stunted, worthless growth or the death of young and old trees, while the numerous worm holes in the wood reduce its commercial value or render it worthless.

The presence of the insects in injurious numbers is indicated (1) by the frequency of the adults on the golden-rod flowers and on the trees from the last of August until in October or later; (2) by the slight flow of sap and by the brownish borings where the young larvæ are at work in the bark during April; (3) by the yellowish borings lodged in the rough bark, in the forks of the tree, and on the ground around the base of the trunk, by the breaking down of the branches and young trees, and by the sickly appearance of the young twigs and leaves during May, June, and July.

This insect appears to be present and more or less injurious in all of that part of the United States which is east of the Great Plains and north of the Gulf States. Published information and reports of forest officials and others indicate that in Oklahoma and Indian Territory and west of the Great Plains the locust is now quite free from injury by the borer, but that these regions will remain exempt is by no means certain.

EXTENT OF DAMAGE AND LOSS.

So extensive is the damage to natural growth, artificial plantations, and shade trees that in some sections within the natural range of the tree in the Eastern States, but particularly in the Middle West, where both the tree and the insect have been introduced, it is considered unprofitable to grow the tree for shade or timber, and in such sections the natural sprout growth is often considered a pest rather than otherwise.

The loss resulting from defective timber, stunted growth, and the death of trees is represented by the difference in value between the damaged growth, or product, and the same if uninjured and healthy. This, if expressed in dollars, would represent a large sum.

CHARACTER OF THE INJURIES.

The destructive nature of the work of the locust borer is a matter of great economic importance. The borer attacks the otherwise perfectly healthy trees, and in addition to causing the detrimental worm-hole defects in the wood, it often kills the trees or renders an otherwise valuable product worthless except for fuel. It is much more destructive in some localities and sections than in others, and also much more

destructive to some trees in the same grove than it is to others. It is more destructive, also, to young saplings and the branches of medium-sized trees than to the larger trees.

The death of a tree is caused principally by injuries to the inner bark and cambium resulting from repeated attacks. Injuries to the wood alone do not result in the death of trees, except when all of the wood is practically destroyed or sufficiently injured to cause the tree to fall or be broken down by the wind.

The commercial value of the wood product is diminished or destroyed by the worm-hole defects, but for certain purposes, as, for instance, fence posts, a limited number of such defects are not detrimental, except so far as they may contribute to decay.

EVIDENCES OF ATTACK.

The first evidence of attack is fine brownish boring dust and wet spots on the bark, first observed in April, when the overwintered larvæ begin to enter the inner bark. As soon as the larvæ begin to groove the surface of the wood and enter the sapwood, their presence, in addition to the wet spots, is indicated by yellowish boring dust mixed with liquids and the gum-like exudations. After all of the larvæ have entered the wood their presence is plainly indicated by the quantities of yellowish boring dust lodged in the loose bark on the trunk, in the forks of the tree or branches, and around the base. At this stage, usually about the middle of May, the badly infested trees which will die are plainly indicated by the failure of the leaf buds to open or by the dwarfed or faded and sickly appearance of the foliage and, toward the last of the month until the larvæ have completed their work in July, by the breaking down of the branches and small trees.

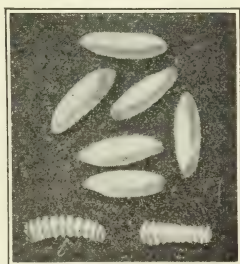


FIG. 2.—The locust borer (*Cyllene robiniae*): a, eggs; b, c, larvæ from hibernation cells. Much enlarged (author's illustration).

FAVORABLE AND UNFAVORABLE CONDITIONS FOR DESTRUCTIVE WORK.

Favorable conditions for the destructive work of the borer appear to consist in the presence of isolated trees and groves in the open, in localities where golden-rod is present or abundant and where less resistant varieties of the tree prevail.

Unfavorable conditions are found in forest growth or large areas of pure stands, or mixed stands where the locust predominates; also in plantations and groves where resistant varieties prevail and where there is no golden-rod or other favorite food for the beetles. It is also found that coarse, thick bark is less favorable than the thinner bark on old and young trees and saplings.

METHODS OF CONTROL.

It should be remembered that all the holes found in a tree and all other damage by the borer are not the work of one generation, but usually that of repeated annual attack during the life of the tree; also that a burrow in the sapwood of a young tree remains the same burrow in the heartwood of the old tree, without change, as long as the tree exists, except in the healing of the original entrance; therefore the number of borers and the annual amount of damage are not so great as they might appear, and, while the females are capable of depositing a hundred eggs each, only a small percentage of the larvæ hatching from them survive the bark-infesting stage or complete their development to adults. This suggests that any method of management which will insure the destruction of a large percentage of the surviving larvæ and beetles each year will reduce the damage to a point where there will be practically no loss.

With our knowledge of the life history and habits of the insect, it is now possible to make definite recommendations and suggestions for its control. Some of those of immediate practical importance are as follows:

TIME TO CUT LOCUST TO DESTROY THE YOUNG LARVÆ.

The cutting of locust for all purposes, including thinning operations and for private or commercial use, should be done during the period beginning with the 1st of October and ending with the 1st of April, the bark removed from the crude product, such as posts, poles, and the like, and the tops and thinnings burned. The removal of the bark from all desirable portions of the trunks of the trees felled during this period is important and necessary, in order to destroy the larvæ before they enter the wood. The work in all cases should be completed before the leaf buds begin to swell on the living trees in the spring.

DESTRUCTION OF INFESTED TREES AND WOOD.

When it is desirable simply to remove and destroy, by burning or otherwise, the badly infested and damaged trees to kill the broods of larvæ, the work should be done in May and June, when all such trees can be easily recognized by the boring dust, fading leaves, broken branches, etc., but the work must be completed before the beetles begin to emerge. Perhaps the best rule applicable to all localities, latitudes, and elevations is to complete the work by the time the flowers have all fallen from the trees, which will vary between different altitudes and latitudes from about the middle of May to the last of June. Another rule would be to complete the work before the earliest varieties of golden-rod begin to show evidences of flowering. This, however, would be the latest that the work should be done, because the beetles begin to emerge by the time the first golden-rod flowers appear.

SPRAYING THE TRUNKS AND BRANCHES TO KILL THE YOUNG LARVÆ.

Experiments have demonstrated that the hibernating larvæ may be killed by spraying the trunks and branches with a strong solution of kerosene emulsion. Therefore, when it is practicable or more desirable to adopt this method for the protection of small plantations, groves, or shade trees, the spraying should be done in the fall or winter, not earlier than November 1 and not later than April 1, or, in other words, during the dormant period of the tree. The following paragraphs explaining the preparation of the kerosene emulsion are taken from Farmers' Bulletin No. 127 of this Department, by Mr. C. L. Marlatt:

Kerosene emulsion (soap formula)—

Kerosene.....	gallons..	2
Whale-oil soap (or 1 quart soft soap).....	pound..	$\frac{1}{2}$
Water.....	gallon..	1

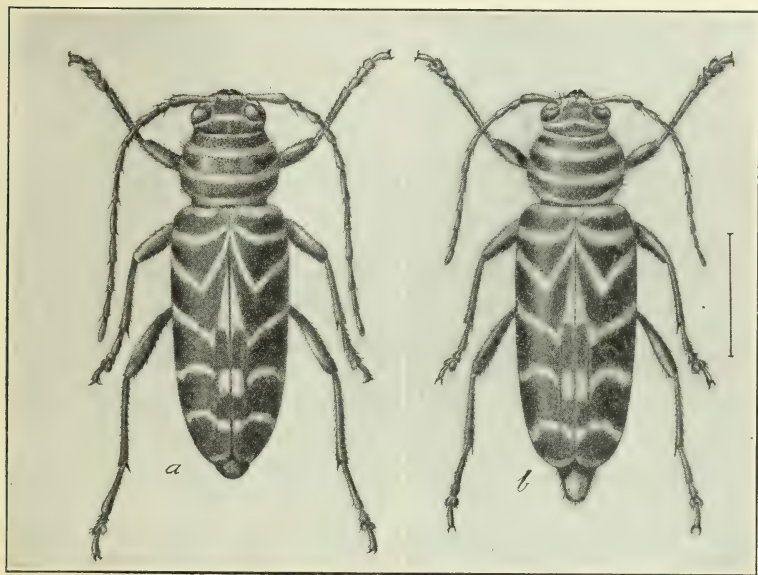


FIG. 3.—The locust borer (*Cyllene robiniae*): *a*, male beetle; *b*, female beetle.
Much enlarged (author's illustration).

The soap, first finely divided, is dissolved in the water by boiling and immediately added boiling hot, away from the fire, to the kerosene. The whole mixture is then agitated violently while hot by being pumped back upon itself with a force pump and direct discharge nozzle throwing a strong stream, preferably one-eighth inch in diameter. After from three to five minutes' pumping the emulsion should be perfect, and the mixture will have increased from one-third to one-half in bulk and assumed the consistency of cream. Well made, emulsion will keep indefinitely and should be diluted only as wanted for use.

For the treatment of large orchards or in municipal work requiring large quantities of the emulsion, it will be advisable to manufacture it with the aid of a steam or gasoline engine, as has been very successfully and economically

done in several instances, all the work of heating, churning, etc., being accomplished by this means.

The use of whale-oil soap, especially if the emulsion is to be kept for any length of time, is strongly recommended, not only because the soap possesses considerable insecticide value itself, but because the emulsion made with it is more permanent, does not lose its creamy consistency, and is always easily diluted, whereas with most of the other common soaps the mixture becomes cheesy after a few days and needs reheating to mix with water. Soft soap answers very well, and 1 quart of it may be taken in lieu of the hard soaps.

In limestone regions or where the water is very hard some of the soap will combine with the lime or magnesia in the water, and more or less of the oil will be freed, especially when the emulsion is diluted. Before use, such water should be broken with lye or rain water employed. * * *

For use on locust trees dilute 1 gallon of emulsion with 2 gallons of soft water.

Pure kerosene and pure petroleum will effectually kill the insects, but may do some damage to the bark of the trees.

Experiments with carbolic emulsion indicate that this preparation is of no value to kill the young larvæ.

DAMAGE TO CUT WOOD AND DANGER OF INTRODUCTION INTO NEW LOCALITIES.

We have determined that after the borers have once entered the wood they may complete their development in the cut and dry branches. They will evidently do so, therefore, in posts or other material manufactured from trees cut between the first of May and the middle of September. From this it is plain that locust should not be cut during that period for any purpose except to destroy the borers, or, if it should be necessary to cut it, the tops should be burned and the logs submerged in ponds or streams for a few days before they are shipped or manufactured. This is very important, both to prevent further damage to the manufactured material by the borers remaining in the wood and also to prevent the introduction of the insect into the Far West and other sections of the country which are at present free from it.

SELECTION OF LOCATIONS FOR EXTENSIVE PLANTINGS.

The fact that there are many sections and localities of greater or less extent within the natural home of the locust and its insect enemies where, from some unknown cause, the tree grows to large size and old age without perceptible injury from borers and other insects suggests the importance of selecting such localities for any proposed extensive operations in the line of artificial planting or utilization of natural growth. It will be found, however, that no area of considerable extent, even in such localities, is entirely free from this and other destructive insect enemies, and that certain precautions and well-planned methods of management with reference to their control will be necessary.

MANAGEMENT OF PLANTATIONS TO PREVENT INJURY.

In the first place it is necessary, in order to provide against future losses from the borer, that a thorough survey be made in May and June, not only of the area to be utilized, but of the entire neighborhood for a radius of a mile or more from its borders, for the purpose of locating and destroying scattering trees and groves which are more or less seriously infested or damaged by the borer. It would seem that the control of such large areas, by purchase or under a plan of cooperation between the owners of the land or trees, is one of the most important requisites for success in preventing future losses from the ravages of this and other insects in small as well as large plantations. In fact, it is the writer's opinion that with this precaution properly and continuously carried out, locust may be successfully protected from the borer in any locality.

In the subsequent management of plantations and of natural forest and sprout growth it is important each year to locate and destroy the worst infested trees for the purpose of killing the borers in the wood and to conduct the thinning and commercial cutting operations during the period between October of one year and April of the next, in order to destroy the young borers before they enter the wood.

Worthless, scrubby, borer-infested trees should be killed outright by stripping the bark from 4 or 5 feet of the lower stem during August to prevent sprouts and seed production from them and at the same time to destroy the eggs and young borers. Trees deadened in this manner will usually be so completely killed that not a single root sprout will appear. Therefore this method is of special value in preventing sprout reproduction from inferior individual trees.

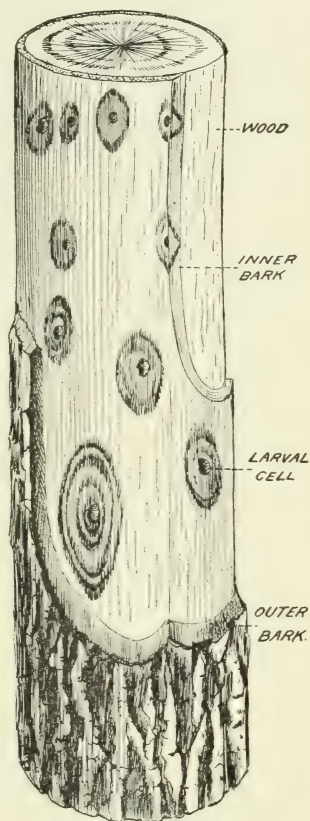


FIG. 4.—The locust borer (*Cylloceria robiniae*): Hibernation or larval cells in outer portion of living inner bark. About natural size (author's illustration).

BREEDING AND PROPAGATING BORER-RESISTANT TREES.

The fact that some trees are to a greater or less extent immune from attack or injury by the borer, while adjacent ones in the same grove are attacked year after year and seriously damaged, suggests the idea of

breeding races and varieties of the species which would be permanently immune.

Breeding experiments have been begun in cooperation with the Bureau of Plant Industry and the Forest Service, but it will require several years to get definite results. In the meantime, however, it is important that seed and cuttings for commercial planting should be selected as far as possible from trees which show least damage from the borer and are otherwise vigorous and healthy. From a well-established principle in the heredity of plants and animals this practice of propagating from the best examples must certainly yield better results than would follow a disregard of the character of the trees from which seed or root propagations are made.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *February 1, 1907.*

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United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE GRASSHOPPER PROBLEM AND ALFALFA CULTURE.

By F. M. WEBSTER,

In charge of Cereal and Forage-Plant Insect Investigations.

SPECIES RESPONSIBLE FOR DEPREDATIONS.

While specimens of the species of grasshoppers actually engaged in devastating alfalfa fields have not always accompanied complaints of their ravages, it is nevertheless possible, taking the data secured by Government and State officials in connection with information from correspondents, accompanied by specimens of the insects actually committing these depredations, to fix the responsibility—largely at least—upon two species. One of these is known as the differential grasshopper (*Melanoplus differentialis* Thos., fig. 1) and the other as the two-striped grasshopper (*Melanoplus bivittatus* Say., fig. 2).

Other species of grasshoppers have probably at times been more or less involved, as it is rarely that material submitted with a complaint of damages does not include more than one species; on the other hand, species depredating on other crops on the same farm or ranch are often submitted under the supposition that they are like those seen at work in alfalfa. A notable case in point is that of the yellow-winged or pellucid grasshopper (*Camnula pellucida* Scudd.), which, while very destructive to grain and grass crops, is said to work but little injury to alfalfa. However, as all grasshoppers likely to become involved in this or similar depredations have much the same habits and all are probably susceptible to the same treatment, the question of species is not one to interest the farmer particularly, beyond the matter of his ability to determine for himself which one is the worst pest and to apply his measures of suppression more especially with reference thereto.

THE MEASURES HEREIN DESCRIBED ARE APPLICABLE ALSO TO CLOVER CROPS.

While this circular is primarily for the benefit of the alfalfa grower, the measures of suppression recommended may be applied in the clover fields of the eastern section of this country with equally good results. Indeed, the two species here discussed are at times destructively abundant in the red-clover fields of the Middle West, and the writer has there used the "hopperdozer" to advantage.

EARLY DEPREDACTIONS.

With the rapid increase in the culture of alfalfa throughout the country west of the Mississippi River there has come the problem of protecting this crop from attacks of several species of grasshoppers or locusts. The reason for this state of affairs is not at all obscure, as in order to breed freely and in destructive numbers these grasshoppers require two conditions: First, an undisturbed soil for the protection of their eggs after these have been deposited, and, second, an early food supply for the young in spring. No other crop comes so near supplying these conditions to an ideal degree as does alfalfa.

Thus it is that the farmer in this section of the country has from the beginning of alfalfa culture been sorely beset by these pests, whose destructive hordes might even now be said to follow closely in the footprints of the reclamation engineer.

SERIOUSNESS OF INJURIES.

Hardly a season passes during which more or less serious outbreaks are not reported in different localities, and the aid of this Bureau is frequently invoked in destroying these grasshoppers or otherwise lessening their ravages. Thus during the year 1905 1 such outbreak was reported from California, 7 from Colorado, 1 from Idaho, 10 from Kansas, 3 from New Mexico, 2 from Utah, and 1 from Texas. It is in no wise likely that these numbers indicate more than a minor portion of the destructive outbreaks of these pests that actually occurred over this territory, and the seriousness of some of these outbreaks is indicated by the fact that as many as 12 complaints were received from a single locality. In fact, the probabilities are that, as this agricultural industry increases, the amount of injury inflicted by these insects will greatly increase in future unless measures are taken to control them.

DESCRIPTIONS OF THE TWO PRINCIPAL ALFALFA-AFFECTING SPECIES.

The differential grasshopper (fig. 1) is about $1\frac{1}{2}$ inches long, its wings expand about $2\frac{1}{2}$ inches, and it is of a general bright yellowish-green color. There is, however, a nearly black melanic form that does

not seem to differ otherwise from the normal. The head and thorax are olive-brown, and the front wings are of very much the same color, without other markings but with a brownish shade at the base; the hind wings are tinged with green; the hind thighs are bright yellow, especially below, with four black marks; the hind shanks are yellow, with black spines and a ring of the same color near the base.



FIG. 1.—Differential grasshopper (*Melanoplus differentialis*). Natural size (after Riley).

The two-striped grasshopper (fig. 2) varies in color from a dull green to a dull brown, with a distinct yellow stripe extending on each side from the upper part of the eye to the end of the wing. The male is about $1\frac{1}{4}$ inches long and the female about one-fourth of an inch longer. This grasshopper may be so easily recognized from

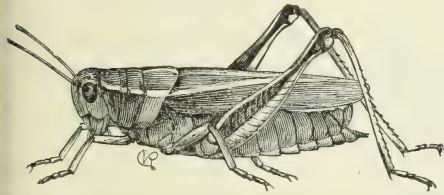


FIG. 2.—Two-striped grasshopper (*Melanoplus bivittatus*). Natural size (after Riley).

the accompanying figure that further description is unnecessary.

The young are very much like those of the Rocky Mountain grasshopper or locust (*Melanoplus spretus* Thos.), shown in figure 3.

DISTRIBUTION OF THE TWO SPECIES.

Although both these grasshoppers seem to be generally distributed over the country, the differential grasshopper rarely becomes destructively abundant east of the Mississippi River. It is very decidedly so, and with great frequency, however, to the west of the Mississippi, while, though extending from Maine to California, the two-striped grasshopper is sometimes disastrously abundant, locally at least, as far east as Ohio.

In the red-clover-growing sections of the country the two-striped species is probably very much the more destructive of the two, though even as far east as Indiana the differential grasshopper does considerable injury to fruit trees by gnawing the bark from the twigs.

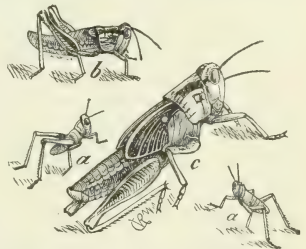


FIG. 3.—Rocky Mountain grasshopper or locust (*Melanoplus spretus*): a, a, newly hatched larvæ; b, full-grown larva; c, pupa. Natural size (after Riley).

LIFE HISTORIES AND HABITS.

The eggs are deposited in the ground in masses, inclosed in more or less kidney-shaped pods, in late summer and fall, after the manner

shown in figure 4, which illustrates the oviposition of the Rocky Mountain grasshopper or locust. The females seem to prefer a moderately compact, rather damp but not wet soil which is rarely disturbed by the plow or other cultivating implement. It will thus be seen that the alfalfa fields throughout the irrigated sections constitute an ideal breeding ground. Winter is passed in the egg state, the young hatching in spring and reaching maturity in summer, and there is but one annual generation. Neither of the two species is migratory. Their flight is rather clumsy, and they do not remain long on the wing before alighting.

NATURAL ENEMIES.

Upward of 100 species of birds are known to feed to a greater or less extent upon grasshoppers, but probably the most useful in this

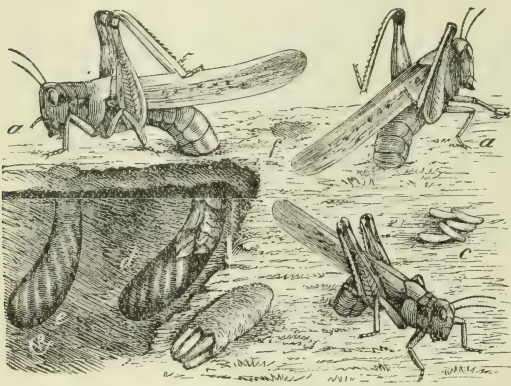


FIG. 4.—Rocky Mountain grasshopper or locust (*Melanoplus spretus*): a, a, a, female in different positions, ovipositing; b, egg-pod extracted from ground, with the end broken open; c, a few eggs lying loose on the ground; d, e show the earth partially removed, to illustrate an egg mass already in place and one being placed; f shows where such a mass has been covered up. (After Riley.)

direction are quails, prairie chickens, the sparrow hawk and Swainson hawk, the loggerhead shrike, all cuckoos, the cowbird, all blackbirds and meadowlarks, the catbird, and red-headed woodpecker. That domestic fowls are especially fond of these insects goes without saying. Skunks are very fond of grasshoppers, and are esteemed by the Bureau of Biological Survey as the most useful of mammals; they therefore deserve

protection rather than destruction by the farmer. Toads and probably some of the snakes add these insects to their bill of fare.

Of the insect enemies, the grasshopper mite (*Trombidium locustarum* Riley) is often found infesting grasshoppers in great numbers. It collects under the base of the wings, sometimes causing them to stand out from the body. While these mites probably destroy many grasshoppers, it is possible that their value to the farmer has been overestimated. There are several species of parasitic flies that frequently destroy immense numbers of these grasshoppers. Of these *Sarcophaga cimbicis* Towns., *S. hunteri* Hough, and *S. georgina* Wied. (fig. 5) sometimes sweep these locusts off in myriads. Under date of August 7, 1906, Mr. John Hunton, of Fort Laramie, Wyo., forwarded to the Department a quantity of dead differential grasshoppers that he had found on different weeds and grasses over an

area of about 6 acres, mostly in alfalfa. He stated that although the live grasshoppers were yet very thick, many appeared weak and in a dying condition. When received the material was simply a mass of decaying bodies of grasshoppers and among them were both maggots and pupæ of *Sarcophaga georgina*. These flies deposit minute, elongated, ivory-white eggs on the surface of the bodies of the grasshoppers. The young maggots hatching from these make their way directly into the body of their host, and as they grow and develop there they feed upon the living insect. When full grown the maggots go into the ground and within a brown case transform to flies.

While all of these natural enemies do much to hold the pests in check, there are two or three vegetable parasites that also kill off myriads of them, the dead bodies of the grasshoppers destroyed thereby often being conspicuous objects as they cling to the weeds and grass where death overtook them (see fig. 6). One of these fungous parasites is the same as that attacking the chinch bug, and is known to science as *Sporotrichum globuliferum*. A group of grasshoppers that have been killed by this fungus is shown in figure 7.



FIG. 5.—*Sarcophaga georgina*, a parasitic fly that destroys grasshoppers. Much enlarged (original).

While it will be seen that there is no lack of natural enemies of these grasshoppers, and while all of them are of benefit to the farmer, they do not and never will afford absolute protection from the ravages of these pests in the alfalfa fields. The reason for this is plain. By growing a single plant over large areas the farmer produces an unnatural condition and offers unnatural advantages for the development of the enemies of this plant, the grasshoppers. It is really the number of plants that invites insect attack. So, also, it is the great number of grasshoppers congregated together in masses that invites attack from natural enemies, and it is only when this condition is present that these natural enemies become sufficiently abundant to offer the farmer prompt and effective relief. In other words, the natural enemies, however much restraining force they may present, are always too far behind to wholly prevent occasional outbreaks of

these grasshoppers. The farmer, having undertaken the cultivation of alfalfa in large areas under conditions preeminently favorable for the development of grasshoppers, must now throw some restraining element into the other side of the scales in order to preserve the balance. It thus comes about that artificial repressive measures must be put into play in order to counteract, as it were, the effect on

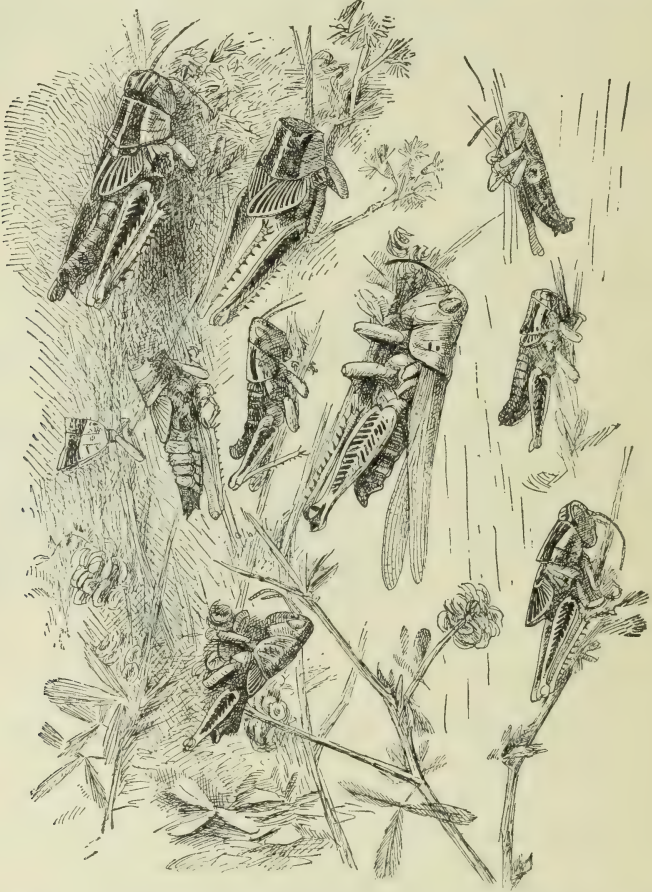


FIG. 6.—A view of grasshoppers dead and dying from fungous disease. Natural size.
(From Howard.)

nature of a preponderance of alfalfa plants—a vastly greater number than would be produced under natural conditions. And this brings us to a consideration of preventive and repressive measures.

PREVENTIVE AND REMEDIAL MEASURES.

Preventive measures, as here restricted, apply to a period antedating the hatching of the young; while remedial measures are such as deal with the insects after hatching and with methods of destroying them.

While many modes of procedure have been advocated, tending to ward off impending attacks, and perhaps even a greater number of devices constructed and mixtures compounded for the destruction of grasshoppers, we will here consider only such as are readily and cheaply obtainable by the farmer and ranchman and those most practical in application.

DESTROYING THE EGGS.

Destroying the eggs of the grasshoppers seems to be the only preventive measure that promises to be worth while attempting, except, perhaps, the destruction of the young as they are hatching.

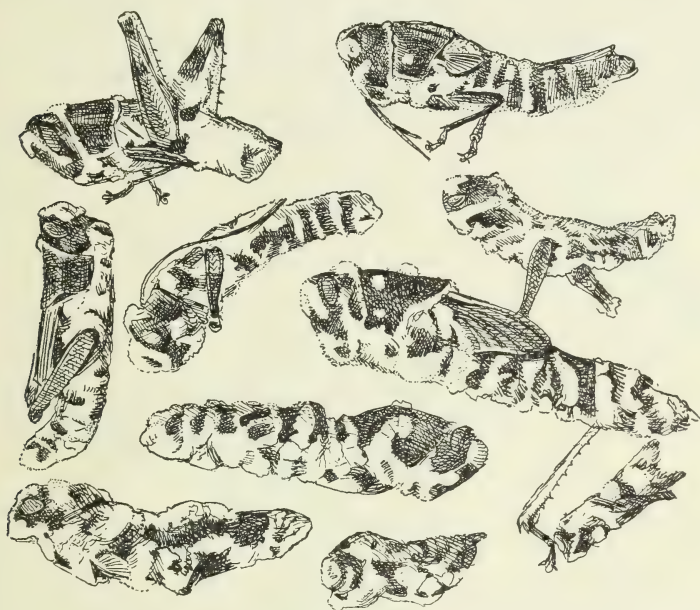


FIG. 7.—Grasshoppers killed by fungus, *Sporotrichum globuliferum*. (After Bruner.)

Destruction of the eggs may be accomplished by either plowing, harrowing, disking, or cultivating, in the fall or winter, all roadsides, ditch banks, margins of cultivated fields, uncultivated fields, and grassy margins along fences. In short, all waste lands that it is possible to reach in this manner should receive attention, unless it is known that no eggs were deposited there.

The soil need not be stirred deeply, 2 inches being a sufficient depth to accomplish the desired effect; and circumstances will probably dictate the kind of tool or tools that a farmer ought to use and where to use them. There is no doubt whatever that if this measure were put into operation at the proper time, in whatever manner is most practicable, disastrous outbreaks the following spring would be forestalled and prevented. Except in cases of isolated farms or

ranches, there should by all means be concerted action in this movement.

Where fields can be quickly inundated and the water promptly run off, as is frequently done in rice fields, the young grasshoppers may be killed by flooding the field for a day or two just as the eggs are hatching. If close watch is kept to determine just when the young grasshoppers are hatching, and prompt action taken at this time, much good can be accomplished; but as soon as the young begin to move about, flooding will avail but little, as the grasshoppers will climb to the upper part of vegetation beyond the reach of the water.

DESTROYING THE INSECTS.

Under this head will be discussed those measures which should be resorted to when the grasshoppers, having hatched from the egg, are threatening alfalfa fields from within or without, or both.

The hopperdozer.—On level or comparatively level land this implement can be used to good advantage in collecting grasshoppers of all ages—from the youngest to the adults. There are many modifications in the construction of these hopperdozers, but the form here described and figured, the writer has had made for him, and he has employed it in the fields and knows from experience that its use is both practicable and efficient. It is constructed of sheet iron, preferably galvanized, of reasonable thickness to insure strength, and, except for the end pieces, made of a single sheet 10 or 12 feet long and 26 inches in width. The front is formed by turning up one edge a couple of inches, and the back may be turned up a foot, thus making a shallow pan 1 foot wide, with the back the same height and with a front 2 inches high. Ends are riveted in and soldered, as shown in figure 8. Runners of old wagon tire are placed at each end (*a*, *b*), and another in the center (*c*) is turned over in the front and back to strengthen the pan at these points. These runners are riveted to the pan, as shown, and should extend both backward and forward in order to overcome to some extent the inequalities of the ground and cause the hopperdozer to run more smoothly. By soldering it about the heads of the rivets the pan will be made water-tight. The pan is filled with water on which is poured enough kerosene to cover it with a film, a horse is hitched to the end runners, and the outfit is then ready for use. As the hopperdozer is drawn over the ground the locusts will either jump into the kerosene and water direct or against the back and drop into it and there be killed. By using longer, wider, and heavier sheet iron a larger and stronger pan can be made and this further strengthened by additional runners; a horse can then be hitched to each end, or the pan may be mounted on low wheels. The whole thing is easily constructed, inexpensive, and once made may be put into service year after year as needed. The

only place where its use will prove more or less impracticable will be on hilly or rocky lands or on that not yet cleared of stumps.

Poisoned baits.—Here again we have an inexpensive, practical way of dealing with these grasshoppers even when, as is frequently the case, they breed in the alfalfa fields and the protection, whatever it may be, must be applied there. What has come to be known as the “Criddle mixture” is giving most satisfactory results on the ranches of both the United States and Canada. The mixture is composed of half a barrel of fresh horse droppings in which is mixed 1 pound each of salt and Paris green. If the horse droppings are not fresh the salt is dissolved in water and mixed with the manure and poison. When this mixture is scattered freely about where the grasshoppers are abundant they seem to be attracted to it, for they devour it readily and are poisoned thereby. Dr. James Fletcher, entomologist for the Dominion of Canada, cites an instance where

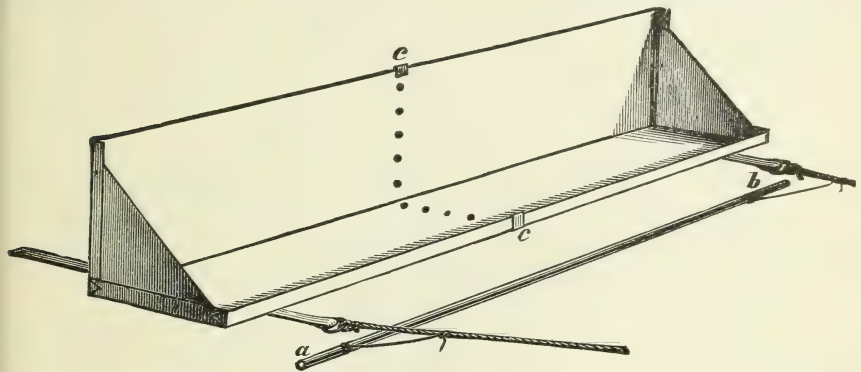


FIG. 8.—“Hopperdozer.” A simple coal-oil pan, to be drawn by horse. (After Riley.)

this mixture had been scattered freely around the edges of a field and states that this particular field stood out as a green patch in a brown plain, as it was situated in the midst of fields where nothing had been done to destroy the grasshoppers. This Criddle mixture now seems preferable to the poisoned-bran remedy that has given and still continues to give beneficial results, for it is less expensive than the latter and less likely to poison other animal life.

COOPERATION.

Cooperation between farmers or ranchmen is of the utmost importance, whether the hopperdozer or poisoned baits be used. On some of the more extensive ranches the owners can protect themselves by reason of the great extent of territory that is under the control of a single individual, but among smaller holdings cooperation is very essential.

FORESTALLING OUTBREAKS.

The ranchman would style this "watching out for trouble." By this is meant the careful watching of the fields for the appearance of the grasshoppers. When these are found to be present, do not wait to see what they are going to do, but prevent their doing anything by putting into practice, before any damage has been done and while the grasshoppers are very young, whatever measures are to be used. It usually requires several days to poison the grasshoppers, and large areas can not be traversed with the hopperdozers in a day. Do not then wait to see what the grasshoppers will do, but see to it that by taking them at the start they are prevented from doing any harm.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *February 20, 1907.*

[Cir. 84]

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CIRCULAR NO. 85.

Issued March 29, 1907.

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE SPRING GRAIN-APHIS.

(Toxoptera graminum Rond.)

By F. M. WEBSTER,

In Charge of Cereal and Forage-Plant Insect Investigations.

The species which forms the subject of the present circular (see figs. 2), and which is commonly known in the Southwest as the "green bug," is probably an imported insect.¹ It was first described by Dr. C.

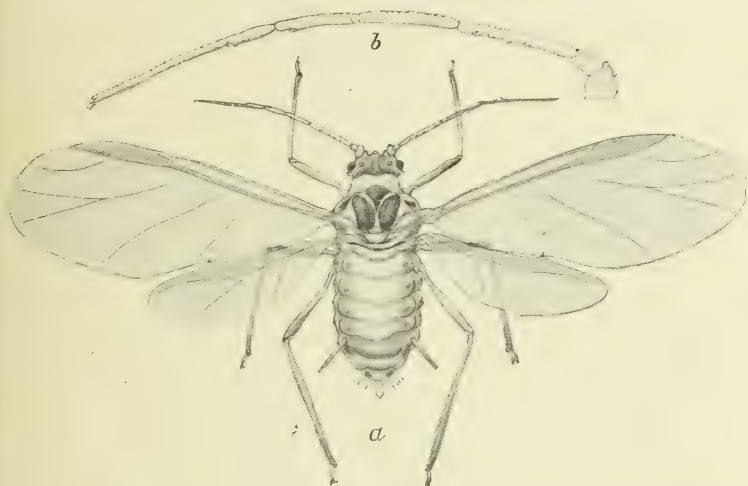


FIG. 1.—The spring grain-aphis (*Toxoptera graminum*): *a*, winged migrant; *b*, antenna of same. *a*, much enlarged; *b*, highly magnified. (Original.)

ndani—probably from Bologna, Italy—in 1852, just thirty years prior to its discovery in America. Rondani states that in June the winged migrants were so abundant in the streets of Bologna as to cause the habitants great annoyance. The first time the insect came to notice America, specimens were sent to the Department of Agriculture, but in what locality is not known. In June, 1884, it was found in some abundance near Cabin John, Md., on wheat. A few days later, that is, about the first of July of that year, the writer found it infesting the wheat in his breeding cages at Oxford, Ind., where he was temporarily located as a field agent of this Department.

¹For technical descriptions in English of the winged and wingless females of this grain-aphis see Pergande, Bul. 38, Div. Ent., U. S. Dept. Agric., p. 18, 1902.

This pest seems to be rather erratic in its outbreaks in both Europe and America. To the agriculturist it suddenly appears in immense swarms on the grain in the fields in spring, ruins the crop over large areas of country, and does not reappear in destructive numbers, perhaps, for many years. The fact is, however, that it can be found in the grain fields during any year, throughout the region it infests, although it may not be sufficiently abundant to work serious injury. The extreme rapidity with which this insect multiplies, unless restrained by natural checks, gives color to the farmer's belief in its sudden appearance, for within a few weeks, from numbers too few to be readily noticeable, it will develop myriads that swarm over the green plants, turning whole fields of thrifty grain to brown, dwarfed plants that produce no heads. or else, reaching a height of not more than 6 to 8 inches, have heads that are foreshortened and nearly devoid of kernels. Thus it is that within the short space of less than twenty years this aphid has come to be one of the worst pests of its kind in the grain fields of the south-central portion of our country.

SEASONAL HISTORY.

The life cycle of this insect does not appear to differ from that which is usual among aphides. The single generation of males and sexual or egg-laying females appears, as far north, at least, as latitude $40^{\circ} 27'$, in October, but possibly earlier to the south. The egg-laying female is wingless and may be easily distinguished by her position on the plant, the body being held almost at right angles instead of parallel to the leaf. She may be further identified by the eggs, which show through the skin, their outlines appearing like lateral oblique lighter lines on the abdomen.

The eggs, which are glossy green immediately after deposition, but later turn jet black, are laid among the grain plants in the fields. Possibly some are placed elsewhere, but if so the writer has failed to find them. While these aphides overwinter in the egg state, they also pass the winter as viviparous females in the fields as far north as latitude $40^{\circ} 27'$, where the writer has found them reproducing by the first of April. The writer has kept them breeding within doors where the temperature during the night frequently fell below the freezing point and ink was frozen in the inkstand on the desk. In this way they were reared throughout the entire winter of 1889-90 at Lafayette, Ind. In the same locality, in 1884, they were breeding in the fields until after the middle of December. There is no doubt whatever that in the South, and even as far north as St. Louis and Cincinnati during mild winters, the species breeds in this way during the entire winter, though the eggs deposited in fall probably do not hatch under such low temperatures, but remain unhatched until spring.

When the foliage of the cultivated grains becomes too old and toughened to afford them sufficient nourishment, the young—as is usual among aphides—develop to winged viviparous females (i. e., winged females that give birth to living young, fig. 1, *a*) and forsake the grain fields. Thus it is that the migration from the grain to the alternate food plant takes place in June, while in the fall of the year the aphides return to the fields instead of leaving them, although the latter is the rule with most of the other species whose habits are well known. It is this variation from the usual habits of allied species that renders this particular aphid so destructive in grain fields and its control so exceedingly difficult.

With the appearance of the young grain in the fields in autumn the aphides again appear, being represented by winged females that soon begin giving birth to young, and various sizes of the latter according to age may frequently be observed surrounding the mother on the leaves.

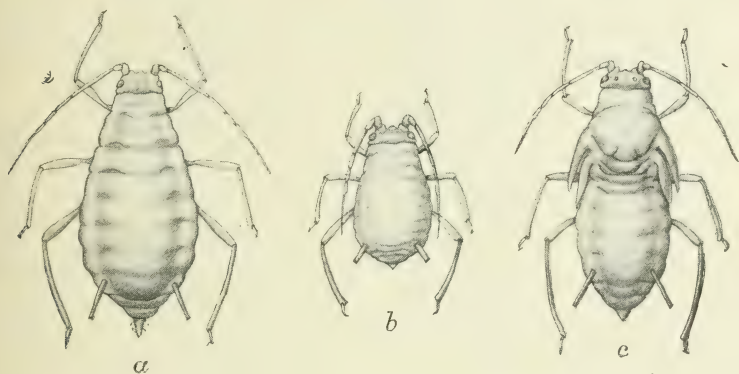


FIG. 2.—The spring grain-aphid (*Toxoptera graminum*): *a*, wingless female; *b*, larva; *c*, pupa. Much enlarged (original).

Young develop to adults and themselves begin to reproduce within the space of a week, so that in favorable weather several generations may be fully represented on the same plant by young of all ages and winged and wingless females.

RAPIDITY OF INCREASE.

In experiments with a winged female in April, in Indiana, the writer obtained 37 offspring within the period of eighteen days, and at the end of this time some of her firstborn were themselves grandmothers. From the writer's experience with allied species it is probable that the wingless female is much more prolific than the winged female, so that it would be entirely within reason to suppose that a wingless mother would be capable of producing at least double the number of young mentioned above within a slightly more extended period of time. It will thus be seen that within a brief period, under favorable circum-

stances, a comparatively few females may become the progenitors of the enormous swarms of these insects that overrun and destroy fields of grain over vast areas of country.

FOOD PLANTS.

The writer has found this grain aphid breeding freely on wheat, rye, oats, barley, and corn, though it seems to prefer wheat and oats. Orchard grass (*Dactylis glomerata*) seems to suit the taste of these insects almost as well as wheat, and it is probably to this and some other grasses that the winged females migrate when they forsake the grain fields in June.

Although the writer failed to rear the insect from *Eragrostis*, *Panicum*, *Ixophorus* (*Setaria*), *Agrostis*, and *Bromus*, it is quite probable that it may be found on some of these, as it is known to occur on some of these grasses in Europe. Rondani gave as food plants oats, wheat, spelt, couch grass, *Hordeum murinum*, soft chess (*Bromus hordeaceus*), and corn. In 1863 Passerini added sorghum, and in 1900 Del Guercio gave the food plants as wheat, barley, oats, corn, orchard grass, *Bromus* sp., and *Lolium perenne*. It seems quite likely, therefore, that the present list of this insect's food plants in America may in future be considerably enlarged.

DISASTROUS OUTBREAKS IN AMERICA.

While more or less common every year, the occurrences of this grain aphid in such destructive abundance over such a large area of country at such long intervals of time are somewhat puzzling phenomena. When first met with by the writer, in 1884, the insect in question was not at all injurious, and it was more than five years later that it was again encountered—this time as a serious pest. This was the outbreak of 1890, which proved so disastrous to wheat and oats over a section of country extending from Texas to northern Missouri, through southern Illinois and Indiana to eastern Kentucky and Tennessee. Oats were destroyed as far north as Franklin, Ind., latitude 39° 30'. Though quite abundant at times, this aphid did not again cause serious injury until in 1900, when the Southwest again suffered an outbreak which, while even more serious in Texas than was the one in 1890, did not extend so far northward. The present year (1907) there is every indication of a recurrence of the pest, for as early as January this insect was reported by Mr. W. D. Hunter, of this Bureau, as destroying the fall wheat and oats in northern Texas.

NATURAL ENEMIES.

Not only is this aphid enormously parasitized, but toward the last of May and in early June both young and old are devoured by lady beetles and their larvæ, great numbers of which can be observed at work in

infested fields. The species that have been most conspicuous in this work are *Coccinella 9-notata* Hbst., *C. sanguinea* L., *Hippodamia parenthesis* Say, and *H. convergens* Guer. (fig. 3). *Megilla maculata* De G. is rarely seen with the preceding in infested fields.

Of the hymenopterous parasites *Lysiphlebus tritici* Ashm. is especially useful. In southern Indiana, in 1890, this little slender, black, four-winged fly became excessively abundant and destroyed myriads of the pest. When at work this diminutive enemy of these aphides may be seen running over the plants, thrusting its ovipositor into their bodies. Soon thereafter the body of the parasitized aphis becomes swollen and rounded, and at the same time the skin hardens and changes in color to a leather-brown. Shortly after, a circular disk is cut by the parasite in the body wall of its host, and pushing this out the fully developed



FIG. 3.—*Hippodamia convergens*, a lady beetle which devours the spring grain-aphis: a, adult; b, pupa; c, larva. All much enlarged (from Chittenden).

insect makes its way forth to at once begin laying eggs in the bodies of others of its host, both old and young. In southern Indiana, in 1890, these parasitized individuals became so abundant on the leaves of the grain as to add materially to the brown color due to the effects of their own feeding on the plants, and their presence could be noted from a considerable distance. Prof. E. Dwight Sanderson, while at the Texas Experiment Station, came to the conclusion that in Texas the natural enemies ordinarily destroy such large numbers of this pest that it is held in check thereby. The writer came to a similar conclusion many years ago, and concluded, further, that the abundance of these parasites throughout the area in which this aphis is destructive is primarily regulated by the weather during the time intervening between November and May.

METEOROLOGICAL INFLUENCES.

Attention has already been called to the fact that the spring grain-aphis can breed in the fields during the prevalence of a temperature that would render most insects inactive. It seems almost equally clear that serious and widespread outbreaks of this insect are due to a lack

of a sufficient number of parasites to hold it in check. Added to this is the fact that disastrous outbreaks have followed mild winters, succeeded by a spring that was below the normal in temperature and more or less stormy. The writer has observed, in the case of other aphides, that seasons of unusual abundance are preceded by cold, wet, and usually "backward" springs. The situation, then, is probably this: The pest is ordinarily kept down by its natural enemies, but during open winters—not sufficiently mild, however, to render these enemies active—it breeds unrestrained, and the exceptionally cold, wet spring enables it to continue breeding while the parasites are still inactive; thus the pest is enabled to get the advantage in point of numbers and work its devastation before the natural enemies can become sufficiently abundant to overcome it.

It can be seen, therefore, that although the farmer's interests are involved, he is unable to determine for himself just what is going on in his fields. He can not foretell the weather months in advance and has no way of knowing when to expect a recurrence of a serious outbreak of the aphid until it is too late to ward off its consequences. The reader will correctly infer from the section on preventive and remedial measures which follows that when spring approaches there is little that can be done by the farmer to improve the situation in case the insects are present in great numbers; but the outlook is by no means the gloomy one that may appear from this statement. Following the spring rains there usually comes, sooner or later, a period of dry, warm weather, and whenever such a period comes the aphides very soon disappear. The reason for this is that their parasites and natural enemies, no longer deterred from activity by cold and wet, immediately begin to breed with extraordinary rapidity and bring about their practical destruction. Should this warm, dry period come later than usual, greater damage is inflicted by the aphides; should it come earlier than usual, serious injury is correspondingly obviated.

PREVENTIVE AND REMEDIAL MEASURES.

We really know far too little of this pest to be able to deal with it satisfactorily. It would seem that the later in the fall grain were sown the less attraction there would be for the pest to invade the fields in fall. Late sowing, then, is about the only preventive measure that can be suggested.

On the subject of treatment for these insects there is not much more to be said. It is probable that a great many of the aphides could be destroyed by rolling the fields as soon as the pests appeared on the leaves in any considerable numbers. Brushing over the fields with a brush drag, made by fastening the ends of limbs or bushes in holes made in a rail or a piece of 4-by-4-inch timber, might also prove beneficial. These two practicable measures are all that can be advised with

any encouragement at present for general relief from the ravages of this insect. In the case of small isolated fields, however, it is possible that some benefit might be derived from dusting with slaked lime at a time when the pest is clustered on the leaves.

Approved :

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *March 14, 1907.*

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United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE CORN LEAF-APHIS AND CORN ROOT-APHIS.

By F. M. WEBSTER,

In Charge of Cereal and Forage-Plant Insect Investigations.

The corn leaf-aphis (*Aphis maidis* Fitch) and the corn root-aphis (*Aphis maidi-radicis* Forbes) are together made the subjects of this circular because both attack growing corn, because it has yet to be clearly shown that there is no direct kindred connection between them, though it is possible that they are distinct species, and because this question of their identity or relationship presents itself to almost every observing farmer.

The leaf-aphis does the farmer little direct injury. The root-aphis, on the other hand, sucks the sap from the roots of his corn, thereby causing the plants to become dwarfed, and in serious cases the leaves turn brown and die. In an infested field the corn will be "spotted," as farmers term it—that is, while the plants on certain areas in the field may make a normal growth and may ear well later on, those on other areas will make little growth, but tassel out after they have become a foot or a foot and a half high, producing the almost worthless ears known as "nubbins" or none at all. Thus the damage to the crop in some fields at times reaches 50 per cent or more, and the annual loss throughout the corn belt must amount to well on toward a million dollars. This root-aphis is really becoming the most serious of the many insect pests of the cornfield, especially where a strict system of crop rotation is not carried out.

THE CORN LEAF-APHIS.

The corn leaf-aphis (figs. 1, 2) was described by Dr. Asa Fitch in 1856 from eastern New York, but it is now known to occur from New England to North Dakota and Texas, as well as on the Pacific coast. Besides, it was found by the writer in great abundance on sorghum on the grounds of the Agricultural College of South Australia, at Roseworthy, February 9, 1889. Professor Lowrie, at that time principal of the college, assured the writer that it sometimes became so excessively abundant as to render the plants obnoxious as fodder for

stock. The insect is known also from Japan. In our own country, while not usually a serious pest, it is said to damage corn, sorghum, and barley in Texas, while Doctor Forbes has noted a reddish discoloration due, he thinks, to a bacterial effect following its occurrence on broom corn.

APPEARANCE AND HABITS.

The corn leaf-aphis is bluish green in color. It appears on corn throughout the Middle West early in July—about the time that the root-aphis begins to decrease in numbers on the roots—sometimes literally swarming on the leaves, husks, and tassels. Here it gives birth to its young, and disappears from the plants only as these ripen and become dry, some individuals even remaining among the husks of belated ears until freezing weather kills them outright.

Whence these insects come, in July, when the first few winged females appear on the leaves of the corn, is a mystery, equaled only



FIG. 1.—The corn leaf-aphis (*Aphis maidis*): Winged female. Much enlarged (original).

by the problem as to the destination of the winged individuals that leave the same plants in autumn. While on the plants they are attended by the little brown ant, the same one that cares for the root-aphis. Thus it will be seen that we have but a fragment of the life cycle of this insect; for, if it is a distinct species, it must occur elsewhere than on corn long before July, and it is equally clear that if distinct it must migrate in the fall to some plant that will afford food for the young the following spring, there to deposit its eggs. We judge this to be the case, as it is known that with most species of aphides there occurs in fall a generation of winged females that fly to the spring food-plant, there to produce a generation of both males and females, the latter laying eggs that do not hatch until spring. From spring until fall there are no males and no eggs; all young

are born alive, after the manner of mammals, and all are fertile females. It will therefore be very clear that with no knowledge of the males and with only this fragment of the life cycle of the females it is impossible to say whether the leaf-aphis is an above-ground form of the root-aphis or whether it is distinct from and wholly independent of that insect.

FIELD EXPERIMENTS.

In October, 1885, the writer transferred some volunteer plants of corn from the field of fall wheat, where they were growing, to some breeding cages. The plants were thickly populated with winged females of the leaf-aphis, and these were carefully secured with the plants, both being subjected to the same conditions which would have influenced them had they remained in the field, except that the ants in attendance were excluded. On May 8, 1886, corn was planted in these cages and grew therein till after the 15th of June—when it was thrown out—without a single individual of either root or aerial form of the root-aphis being on or about the plants.

Dr. S. A. Forbes, State entomologist of Illinois, under whose direction most of the investigations of these insects have been carried out, in summing up the results of a long series of carefully conducted experiments of his own, comments as follows:

The foregoing data confirm our ignorance more than they increase our knowledge, showing, as they do, the failure of all attempts to find or produce a bisexual generation or an alternative food plant of *Aphis maidis*, or to learn how and where it normally passes the winter. Its willingness to feed on winter wheat and ability to breed freely on that plant, its indisposition toward grass or the foliage of the apple, and the natural frequency of successive generations, are the principal other facts evident from these observations.^a

Winged females of the root-aphis occur in summer on the leaves of corn together with those of the leaf-aphis, but never in such immense numbers. The two forms of winged females seem to be distinguishable, but the sexes have never yet been observed to interbreed—indeed without males above ground they could not do so; hence it is yet too much to say whether there are two distinct species, with the males of but one yet discovered, or whether these are two forms of a single species, with as yet undiscovered relationships obscured by long-continued influences of ants. As it is with the root-aphis that the farmer has most to do, that species will be chiefly considered here.

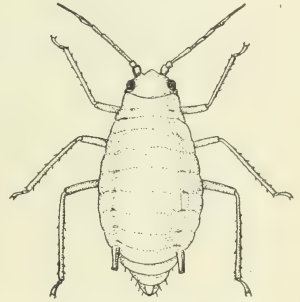


FIG. 2.—The corn leaf-aphis (*Aphis maidis*): Wingless female. Much enlarged (original).

^a Twenty-third Report, State Entomologist of Illinois, p. 133, 1905.

THE CORN ROOT-APHIS.

Although the corn root-aphis (figs. 3, 4) was not definitely described until 1891, its presence in the cornfields of Illinois was noticed by Mr. B. D. Walsh in 1862, near Rock Island, and these two corn aphides were made the subject of a paper contributed by him to the Transactions of the Illinois State Agricultural Society.^a Mr. Walsh, who was afterwards the first State entomologist of Illinois, stated that his attention was called to the "lice" on the roots of corn in this field in the latter part of May, 1862, and about a fortnight later he visited the field in person. He illustrates a section of corn root "as I saw it with my own eyes, swarming with these tiny pests." Further, he states that from wingless specimens, secured at the time of his visit, he afterwards reared 15 winged females. From the fact that the description of the leaf-aphis by Doctor Fitch "agrees



FIG. 3.—The corn root-aphis (*Aphis maidi-radicis*): Winged female. Much enlarged (original).

tolerably well" with that of the species that he found attacking the roots in June, he suspected that the two were identical. An illustration of the winged female reared from the roots does not, however, tend to convince one of the correctness of his opinion, as it best represents the winged root-aphis and rather sustains the fact that the root-aphides were present on the roots of corn at that time, in the vicinity of Rock Island, and that from some of these he succeeded in rearing winged adults in June. While this is not in the least surprising it is nevertheless interesting as being a record of the original discovery of the root-aphis and of the discovery and rearing of the winged female. The statement made that the root-aphis was attended by little brown ants is still further evidence of the validity of these observations, however incorrect Walsh's conclusions therefrom may have been. As a matter of fact, up to about that time spring wheat culture had domi-

^a Vol. 5, pp. 491-497, 1861-64.

nated over the prairie country east of the Mississippi River and north of the Ohio River, so that conditions were not favorable for the root-aphis. But about that time conditions changed and corn culture became dominant, necessitating the continued cultivation of large areas to this latter grain for a greater or less number of consecutive years. Thus this pest was brought into continually increasing prominence, and Mr. Walsh's observations were made about the time of what was probably the beginning of its career of destructiveness.

DESCRIPTION.

For all practical purposes the root-aphis may be sufficiently characterized as follows: The color is bluish-green, slightly whitened by a waxy bloom. The body is oval, and on the anterior part of the back are two short, slender, rather conspicuous cornicles or tubes, either standing erect or projecting slightly backward (fig. 4). The winged female (fig. 3) has a black head and brownish-black thorax, the abdomen being pale green, with about three marginal black spots and numerous small dark specks over the surface. The antennæ are dark, with paler tinge at articulations, and the legs are mostly black. The only form of male known is wingless, like the female found on the roots.

THE ROOT-APHIS AND THE LITTLE BROWN ANT.

Before proceeding further it is necessary to describe a most important and astonishing domestic condition involving the brown ant (*Lasius niger* L., var. *americanus* Emery) and the otherwise helpless *Aphis maidi-radici*. The presence of ants burrowing about young corn plants in the field has frequently attracted the attention of farmers, and damages to the crop are very frequently attributed to them. The species under consideration is one of our most abundant and widely distributed ants, occurring in colonies of from fifty to several hundred in burrows in the fields. While it is of itself harmless, it is in reality responsible for all of the ravages caused by the root-aphis, whose life history and habits it appears to have entirely revolutionized, as will now be explained.

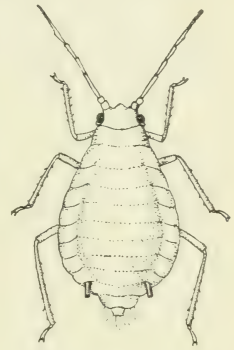


FIG. 4.—The corn root-aphis (*Aphis maidi-radici*): Wingless female. Much enlarged (original).

LIFE HISTORY AND HABITS OF THE ROOT-APHIS.

The normal life history of aphides in general is as follows: The winter is passed in the egg state upon or near the plant upon which the young must first subsist in spring. From these eggs there hatch young

aphides that are all females and these in a short time begin to give birth to living young which are likewise all females. Thus the life cycle goes on, and though there is usually a radical change of food plant, there are neither eggs nor males until autumn, when there is a generation consisting of both males and females, the latter depositing eggs that winter over. This egg-laying female and the male are the unknown forms of the leaf-aphis.

Now, taking up the life history of the root-aphis, we find eggs in the fall, it is true, but only in the burrows of and attended by these ants. If there are eggs, egg-laying females, or males elsewhere they have yet to be discovered. The ants care for these eggs throughout the winter, shifting them about, according to Forbes, as they do their own young, to accommodate them to changes of weather and moisture. In spring, the young, as soon as they hatch from these eggs, are transferred by the ants to the roots of young foxtail grass, smartweed, and even ragweed. The young are carried out to pasture, as it were, during fair weather, but in bad weather, or on cold nights, they are taken back to the burrows of the ants. The plants just mentioned are the ones that push up early in spring in last year's corn lands, and especially in fields that have been plowed and allowed to stand untouched for a week or so. Usually the farmer plows his ground in spring and pays little attention to this early growth of weeds and grass, as he can generally dispose of it as soon as he begins to cultivate the corn, although this is not until the rows of young plants can be followed by the eye across an ordinary field. As soon, however, as the corn plants begin to show above ground the ants not only transfer the young root-aphides from the burrows to the roots of corn, but they will also remove them from the roots of grass and weeds and recolonize them on the roots of young corn. Now these young aphides are all females and within a few days they begin to give birth to young, also all females; these, too, are cared for by the ants, which place them on the freshest and most tender rootlets. This procedure goes on about the roots of corn throughout the spring and summer. Forbes has found that under the most favorable artificial conditions there may be as many as sixteen generations between April 8 and October 10, ten of which may coexist at the same time. It is hardly probable, however, that so many generations can exist under ordinary field conditions; nevertheless it may be rightly inferred from this that the multiplication of the species is enormous. These ants not only transfer the root-aphides from one root to another of the same plant, but will carry them from one plant to another a considerable distance away. In the spring of 1887 the writer placed a number of flowerpots containing young, growing, uninfested corn plants between rows of infested hills of corn in the

field. The corn in the infested hills was then pulled up, exposing the roots on which the aphides were clustered. The little brown ants at once began to carry the aphides to new quarters, and the next day the latter, some of them full grown, were abundant on the roots of the corn in the pots, although there were none on them when the pots were put in place. Ants were observed over a yard away from the plants that had been uprooted, with root-aphides in their mouths, to all appearances searching for a suitable place in which to establish their charges on the roots of corn. Thus it is that from the laying of the eggs in fall to the last or egg-laying generation of the following year this aphid is wholly dependent on the little brown ant for its existence in the cultivated fields, and the farmer can justly charge up his losses through the attacks of the root-aphid to the influences of this ant. But the matter does not terminate here, as will be seen by what follows.

WINGED FEMALES OF THE ROOT-APHIS.

So long as the roots upon which the root-aphides are colonized afford an abundance of nourishment for them, all will be wingless, but as soon as the roots become tough and woody or dry out there will be a generation of both winged and wingless individuals, the former escaping from the burrows about the roots to fly to other plants, and in all probability to other fields, where they may be found on the leaves. The ants usually transfer the wingless individuals to more succulent roots, but seem to pay little or no attention to the winged individuals, letting these make their way out and away. But in May, 1887, the writer was able to watch some of these winged nomadic individuals in a cornfield to which they had migrated and to note the results of their wanderings. A field of corn had been planted on May 18. Five days later there came a heavy rainstorm that flattened the surface of the ground, which was soon incrustated by the action of wind and sun. Four days afterwards there were freshly-thrown-up mounds of earth about some of the corn plants, and ants were busily engaged in and about these and running up and down over the young corn. On examining these mounds and burrows the writer was surprised to find winged root-aphides giving birth to young on the roots, attended by ants. All of these young were very small, at most but a few days old. Other winged individuals were found on the leaves and even on the stems of corn, and when any one of these was placed where the ants could find it, it was promptly captured by an ant and transported to the roots of the corn. Observation showed that as soon as the ants running about over the young corn plants found a winged aphid they made a burrow about the base of a plant, and soon domiciled the wanderer on the root under their guardianship. Then when the aphid began to give birth to young these were promptly removed to another part of the same

root or to another root close by, and there watched over by the patient and industrious ants. The same thing was observed going on about a young plant of fox-tail grass in this same cornfield.

INFLUENCES LIKELY TO PRODUCE FEMALES.

While the production of winged individuals seems to be brought about largely by insufficient food supply, Forbes is of the opinion that the production of egg-laying females is fully as much—if not indeed much more—influenced by the temperature, a low temperature causing them to be produced at any time, regardless of generation; and he himself has secured them from as many as five different generations. In two cases recorded by him the first young produced developed to adults that gave birth to their young, whereas the last developed to adults that laid eggs. These cases, although seeming rather out of the ordinary, illustrate the fact that the insect may adapt itself to widely different autumn conditions; that is to say, an early frost, which presupposes a low temperature, kills the corn but does not annihilate the insect, for an egg-laying generation is thus precipitated and the ants promptly secure the eggs. This egg-laying generation is probably produced in September or October, as these females are found in the burrows of ants at that time. Possibly it is produced earlier to the South. Mr. C. N. Ainslie, of this Bureau, one of the writer's assistants, found the egg-laying females quite numerous in such situations on September 22, at Annapolis Junction, Md. The chief item of interest to the farmer is the fact that these eggs are taken charge of by the ants and kept through the winter.

THE ANT'S CARE FOR EGGS AND YOUNG OF THE ROOT-APHIS.

There is no indication that the ants hunt the fields for egg-laying females; on the contrary, they secure their supply of eggs from females kept for precisely that purpose in their burrows about the roots of corn. This affords ample explanation of the increasing abundance of root-aphides in fields that are cultivated to corn year after year in succession, and it also points to a preventive measure. The object of all of this care on the part of the ants is to obtain from the root-aphis a sweet fluid known as "honey dew." Owing to this peculiar relation, this and some other aphides are commonly termed "ants' cows." Thus the economic importance of this insect and its association with ants is for practical purposes fully accounted for and an explanation furnished as to why farmers are misled into believing that it is the ants that actually destroy the corn. Not only this, but a condition of affairs is revealed which shows why this young growth of grass and weeds that springs up soon after the ground is plowed in spring, pre-

paratory to putting out the young crop, and which usually causes the farmer little concern, is really of vital importance. The farmer rests secure in the knowledge that he can easily kill this growth of weeds and grass later. This is true; but he does not do so until his corn has grown to a size that will permit cultivation, and by this time the ants have transferred the root-aphis to the corn. The aphides are then no longer dependent on the roots of the grass and weeds, so that the destruction of the latter at this time does not seriously affect the domestic arrangements of the ants and aphides.

NATURAL ENEMIES OF THE ROOT-APHIS.

While the leaf-aphis is attacked by a host of parasites, the root-aphis does not appear to suffer in the least from inroads of either parasitic or predaceous insect enemies. This is, perhaps, owing in part to the protection offered by the ants. All natural checks must therefore be meteorological influences, and, as previously shown, these also are to a marked degree overcome by the watchful care of attendant ants.

PREVENTIVE AND REMEDIAL MEASURES.

Preventive measures deal with the pest prior to its becoming established on the roots of corn in the fields; remedial measures, with disposing of it afterwards.

CROP ROTATION.

From the fact that in the midst of the corn belt, and where the root-aphis is known to prove destructive under certain conditions, almost complete immunity is secured where a system of crop rotation has been carried out for many years, involving but one corn crop in the cycle of rotation, it is self-evident that this measure offers the greatest protection from the ravages of this pest. Indeed, it is only where such a system of crop rotation is not practicable that the root-aphis need be considered in farm practice. To the eastward, where there is more general rotation of crops, this pest does but little injury.

Unfortunately, local conditions, often extending over large sections of country, will not permit of crop rotation being generally adopted, and some other plan more feasible must be put into practice. Two other methods may be followed. One of these is practicable throughout the corn-growing section of the country in seasons of not more than normal precipitation during the time intervening between the first plowing of the ground and the first cultivation of the young corn. The other is perhaps best adapted to the southern portion of the country on account of the milder winters.

STIRRING THE SOIL AFTER PLOWING AND BEFORE CULTIVATING THE CROP.

The action of the ants in colonizing the young root-aphides on the roots of young grass and weeds that spring up in the fields almost immediately after plowing in spring has already been explained. Indeed, this is the only pasturage for young root-aphides that is available at that particular period, and if this can be destroyed the pest can not survive until corn roots are available. If, then, the ground is frequently stirred from the time it is plowed until the first cultivation takes place, not only will this pasturage for the pest be destroyed, but the homes of the ants will be continually broken up and a greater or less number of their own young, as well as the young root-aphides, will be killed, while many unhatched eggs of the pest will be destroyed or lost to the ants. This measure involves additional labor, it is true, but in the writer's experience it has proved effective, and, besides, every up-to-date farmer knows that the more the soil is stirred, pulverized, and compacted prior to the first cultivation, the more thriftily will his crop grow when it is fairly started and the more grain will it produce. So, then, the extra labor involved in this practice is not without ample return, aside from the fact that it demoralizes the ants and destroys the root-aphis. The only sections of the country where this is not strictly true are some portions of the South, where the planter must endeavor to curtail the growth of stalk in order to secure larger and more perfect ears. But here, again, corn is not the major crop, it is not grown for several consecutive years on the same ground, and the root-aphis is not so excessively abundant.

LATE FALL OR WINTER PLOWING.

It is in the southern section of the country that the second preventive measure, i. e., late fall or winter plowing, can be best applied. In the corn belt of the more northern section of the Middle West, not only is winter plowing, as a rule, utterly impracticable on account of the more severe weather, but the fodder, instead of being secured as in the East and South, is pastured off after the corn has been husked. To practice late fall plowing, or indeed to fall-plow at all, would mean, therefore, in this northern section, the sacrifice of this important item in farm economy. As far north at least as the latitude of Washington, however, winter plowing is frequently entirely practicable, and there is little doubt that it will prove entirely effective against the root-aphis.

During the winter of 1906 Mr. John Bowie, of Annapolis Junction, Md., winter-plowed the major portion of a 60-acre field in preparation for corn the following season. The plowed portions occupied each of two sides of the field and a narrow headland at one end; thus the unplowed area was left in the middle of the field and this was plowed in

the spring. On July 28 the writer went over this field of corn carefully and found that over the spring-plowed portion nearly every hill of corn was infested by the root-aphis. The crop was an almost complete failure. Much of the corn had been killed out previous to the time of the writer's visit and the remaining part was dwarfed in growth, bore few ears, and such as it had were very small and almost worthless. All over the winter-plowed portion, however, there was every prospect of a heavy yield of both stalk and ears, even to the narrow head-land previously mentioned. An assistant, Mr. Ainslie, visited the field in late September and was able, without information from any person, to locate, to a row, the dividing line between the two plowings. This was clearly visible on account of the difference in appearance in the stubble—the corn having by this time been cut and shocked—and also on account of the number, size, and appearance of the shocks. There was a difference of fully two-thirds in favor of the winter-plowed portions of this field. As the yield of the winter-plowed portion was approximately 75 bushels per acre, the spring-plowed would not exceed 25, showing a probable loss of about 50 bushels per acre. At the market price, 75 cents per bushel, the loss would amount to \$37.50 per acre, to which must be added the loss in fodder. These figures show quite conclusively the amount of damage this root-aphis is capable of doing, as well as what can be accomplished in the way of prevention by thoroughly practical methods.

THE USE OF BARNYARD MANURE.

It seems to be a fact, borne out by field observations, that where ground has been fertilized with barnyard manure the root-aphis does not become so destructive. As far back as 1886, on the experiment farm of Purdue University, at Lafayette, Ind., the writer made some observations which led to the conclusion that proper fertilizers applied to the soil are a general preventive of damage. This was clearly proved by the appearance of the crop on a series of eighteen plats on the university farm. These plats were located side by side and numbered 1 to 18. All had produced corn for the previous six crops, those plats of even numbers not having been fertilized during that time. Plats 1, 7, and 13 had, three and again two years previous, received applications of gas-lime; plats 3, 9, and 15 had received applications of superphosphates during the same years, while plats 5, 11, and 17 had received similar treatment with barnyard manure. The result, up to July, 1886, was that the corn on all plats except those fertilized by barnyard manure was small and uneven in growth, while on plats 5, 11, and 17 the plants were fully a third larger, more thrifty, and far less uneven in height. In fact, these plats could be distinguished from any of the others at a distance from the field. It was unfortunate

that the carrying on of the experiments forbade any examinations of the roots in order to estimate the relative number of aphides inhabiting each series of plats.

EXPERIMENTS IN DRIVING THE ANTS FROM THE ROOTS OF CORN IN THE FIELD.

During June, 1886, a number of experiments were made to test the immediate effect of fertilizers, including salt, upon the aphides, and also to learn if the ants could be induced thereby to abandon or remove their favorites to other plants.

The substances used were two commercial fertilizers (Bunner bone dust and bone guano), barnyard manure, and common salt. A double experiment was made with each. The first two substances were applied (1) by scattering a tablespoonful on the surface of the ground about the plant and sprinkling with water sufficient to wash it at once into the soil, and (2) by drawing the earth away from the roots, scattering the same amount of fertilizer about the roots, then replacing the earth, and sprinkling the surface less thoroughly than with the first. The barnyard manure was well-rotted and a quantity sufficient to fill a pint measure was used in the same way. The salt was used in the same way as the manufactured fertilizers.

The result, a week after, was that the "lice" were still about the roots in every case, and, except where salt was used, they were found in the midst of the substances applied. The salt only drove them from one portion of the roots to another. Sand dampened with kerosene was then applied in the same way, but the surface application had no effect, and that made directly to the roots only drove the aphides from one part of the roots to another, as did the salt.

TREATING THE SEED BEFORE PLANTING.

During the last two years Doctor Forbes, in Illinois, has been testing a great number of substances with a view to treating the seed with some repellent that would render it so obnoxious to the ants that they would not place the aphides on the roots of the young plants. It has indeed seemed possible to take advantage of the well-known fastidiousness of these ants and find something that, applied to the seed, would not injure its vitality, but would give off an odor so disagreeable to the ants that they would shun the vicinity of its application. The writer tried something of this sort in 1887—except that in his experiments substances supposed to be offensive to the ants were placed in the soil about the roots of the corn—but the results were not satisfactory. In treating the seed, however, Doctor Forbes seems to have had very encouraging success and he has permitted the writer to use here the results of his experiments, which are quoted in brief as follows:

The substance found most effective for the treatment of seed corn was a mixture of oil of lemon and wood alcohol. To 1 gallon of wood alcohol add 1 pint of oil of lemon, and sprinkle and thoroughly stir 3 fluid ounces—that is to say, 6 tablespoonfuls—of this mixture into each gallon of corn shortly before planting, making sure that the fluid is equally distributed and that each kernel of corn has its proper share. A thorough stirring after the application of the mixture is all that is necessary. The odor of this compound, which will last for weeks in the ground, is extremely offensive to the cornfield ant, and these insects will not enter corn hills as long as it continues. As the root lice can not get access to the corn or maintain themselves there except by the aid of the ants, the hills remain virtually free from both insects for at least six weeks.

The wood alcohol should not cost more than \$1 a gallon nor the oil of lemon more than \$2 a pint, and the above amount of the mixture will be sufficient to treat the seed for 45 acres, making a cost for materials of less than 10 cents per acre. Care should be taken to buy these substances from thoroughly reliable druggists, the oil of lemon especially being subject to adulteration. If the mixture is not entirely clear when shaken up the materials are impure.

Doctor Forbes has in some cases succeeded by this means in reducing the number of root aphides 89 per cent and the number of ants 79 per cent, which is certainly a very creditable showing for this mixture. The mixture of wood alcohol and oil of lemon is so easily made and the application so inexpensive and simple that it is to be hoped that farmers who have suffered from the ravages of this pest will give the preparation a thorough trial in their fields. While local conditions may prevent the putting into practice of any or all of the other measures of relief here advised, it is difficult to conceive of a situation that would prevent a farmer from treating his seed corn before planting, as recommended.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *April 5, 1907.*

[Cir. 86]

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United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE COLORADO POTATO BEETLE.

(*Leptinotarsa decemlineata* Say.^a)

By F. H. CHITTENDEN,

Entomologist in Charge of Breeding Experiments.

There are few more familiar insects to the farmer and others who lead a rural life than is the Colorado potato beetle, or "potato bug," as it is commonly known; and yet scarcely more than forty years ago the potato crop of the United States had no very important insect enemy. Not many years later this insect had, by its depredations on potato, one of our most valuable food staples, caused as great concern as have the San Jose scale and cotton boll weevil in the past decade, and was also the subject of much study and experiment. Although so common an insect, many are not thoroughly acquainted with its life history and habits and with the best methods of combating it, and this applies particularly to persons farming in districts only recently invaded by the foe. The insect is continually extending its range southward, and many complaints are received from localities where the pest has not become thoroughly acclimated.

The potato beetle, notwithstanding all that has been done to suppress it, is still a pest of great importance. It is interesting as the first known example of an insect native to our Western States being introduced eastward and thence practically all over our country and Canada (except on the Pacific coast) where potatoes are grown. In its early days as a migrant there seemed to have been no check to its eastward spread other than natural barriers, such as rivers and lakes and the Atlantic Ocean, but in the course of years numbers of natural enemies—birds, mammals, and predatory and parasitic insects—

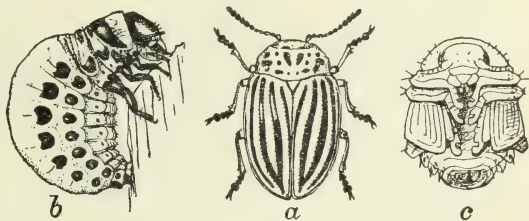


FIG. 1.—Colorado potato beetle (*Leptinotarsa decemlineata*): a, Beetle; b, larva; c, pupa. Enlarged (original).

^a Formerly classified and better known as *Doryphora 10-lineata* Say.

have learned to attack it, and, in the case of the insects, they have multiplied until now they are recognized as important factors in the control of the beetle. The species is interesting also as having led to the first use of an arsenical insecticide, Paris green, on edible plants. Fortunately, with a knowledge of the habits of this insect,



FIG. 2.—Section of potato plant showing Colorado potato beetle at work : *a*, Beetle ; *b,b*, egg masses ; *c,c*, half-grown larvæ ; *d,d*, mature larvæ. Somewhat enlarged (original).

the use of arsenicals, and the friendly assistance of natural enemies, the grower may hold it in practical subjection.

DESCRIPTIVE.

The Colorado potato beetle is so well known that a description seems hardly necessary for most persons, but that there may be no
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danger of confusing it with any related species or with beneficial ladybirds, a few words of description may be given.

The beetle (fig. 1, *a*; fig. 2, *a*) is of robust form, about three-eighths of an inch in length or a little more, and two-thirds as wide as long. It is ochreous yellow in color, and the wing-covers are ornamented with ten longitudinal black lines. The head is marked with a triangular black spot, and the thorax is dotted with ten or more irregular spots and other markings. The lower surface is also more or less marked with black, particularly the tarsi and knees.

The larvæ (fig. 1, *b*; fig. 2, *c, c, d, d*) are quite as well known as the beetles and are very commonly called "slugs." They are dark Venetian red when first hatched, and as they approach maturity become paler. They are slimy, disgusting looking creatures, soft in texture, and from their peculiar coloration and appearance would not be readily handled by anyone without gloves.

The pupa is red like the larva and looks as shown at *c*, figure 1.

The eggs (fig. 2, *b, b*) are orange colored and are deposited in masses.

As this beetle is sometimes confused with one or another of the "old-fashioned potato bugs" (blister beetles), a species of the latter is illustrated here for comparison (fig. 3).

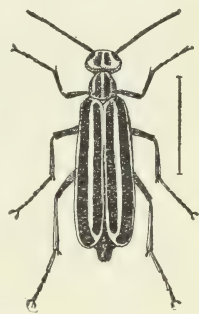


FIG. 3.—Striped blister beetle (*Epicauta vittata*), an "old-fashioned potato bug." (Author's illustration.)

ORIGIN AND DISTRIBUTION.

It has always been believed—and, the writer maintains, with reason, until the contrary can be proved beyond doubt—that the Colorado potato beetle, having become dispersed from Colorado as a starting point, originated as a species in that region. Dr. W. L. Tower, however, in a publication issued in 1906,^a has assumed that this insect had the same origin as its principal wild food plant, *Solanum rostratum*, which he states is essentially tropical, and that the insect has followed the distribution of the plant from Mexico into Texas, New Mexico, and parts of Arizona. He also gives reasons for the belief that *Leptinotarsa decemlineata* has developed from *L. "intermedia* Tower" after changing its habitat, the latter occurring in both Mexico and Texas, and the former not being found in Mexico at all, according to his experience.

HISTORY OF THE INSECT'S SPREAD.

The eastward dispersal of this potato beetle from what is generally considered its original home in the West is of peculiar interest. The

^a An Investigation of Evolution in Chrysomelid Beetles of the Genus *Leptinotarsa*, Carnegie Institution, Washington, D. C., pp. 23 et seq.

beetle appears to have been first associated with injury to potato in 1865. Forty-five years prior to that time it had been recognized as feeding on the sand bur, or beaked nightshade (*Solanum rostratum* Dunal.), a related solanaceous plant peculiar to the Rocky Mountain region. The beetle was described in 1824 by Thomas Say. With the advance of civilization westward and the cultivation of potato in the vicinity of its native home, the insect acquired the habit of feeding upon this more succulent plant, and about 1859 it had spread to the east as far as Nebraska. Two years afterwards it reached Kansas, and later Iowa, which it traversed in three or four years; so that by 1864 or 1865 it had crossed the Mississippi River and invaded the western borders of Illinois. In its spread through Illinois it was described by Walsh as marching through that State "in many separate columns, just as Sherman marched to the sea; the southern columns of the grand army lagged far behind the northern columns." By 1869 it had found its way to Ohio, appearing almost simultaneously in the northern and western portions. During all this time, beginning with the year 1861, the insect had done considerable injury, and by 1870 it had become exceedingly destructive in the North and Middle West, and was continuing its eastward march at an increasing rate. It had now reached the Province of Ontario. By 1872 its depredations in the West had noticeably abated, owing to the effectiveness of natural enemies and to the increasing use of Paris green. Its progress eastward, however, continued, the northern columns becoming established in Pennsylvania and New York, the southern ones reaching Kentucky. The next year it made its first appearance in the District of Columbia and West Virginia, and in 1874 it had reached the Atlantic seaboard and was reported from Connecticut to Maryland and Virginia.

By the centennial year (1876) the Colorado potato beetle had spread over an area composing more than a third of the United States, so that it occupied at that time more or less completely the States of Colorado, Nebraska, Kansas, Minnesota, Iowa, Missouri, Wisconsin, Illinois, Michigan, Indiana, Ohio, Kentucky, the New England States, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, and West Virginia, and the District of Columbia, in none of which was it native except in the State first mentioned. At that time it occupied also portions of Wyoming and southern Dakota—where it was perhaps also native—and a considerable part of the more arable portions of eastern Canada.

The farther spread of this insect, particularly southward, is of less interest and has, in many instances at least, been dependent more or less on the increased cultivation of the potato. The following additional statements as to the insect's progress are taken from data

collated mainly from the records of this office, some of which are published more in detail by Tower.^a In 1877 the beetle appeared in North Carolina and Tennessee. The following year it was reported to be completely overrunning portions of Canada, being found eastward in New Brunswick. In 1879 it was recorded from Manitoba. In 1880 its presence was observed in Texas. Since about 1882 complaints of injuries have been made in Nova Scotia; in 1885, at Savannah, Ga.; in 1888, at Jackson, Miss.; and in Smith County, Tex. In 1892 the species had become abundant in Alabama, and was noticed also in South Carolina. The following year its occurrence was observed by H. G. Hubbard at Fort Assiniboine, Mont., which is evidently the most northern limit of its original habitat, as it was not found there on potato. In succeeding years other localities were added in some of the States which have been mentioned, but little of positive interest adding to its known distribution has been learned since 1893. It should be stated, however, that the species has been found at Jacksonville, Fla.; in southern Louisiana, and at San Antonio, Tex., but these extreme localities do not indicate permanent location.

PRESENT DISTRIBUTION.

The natural spread of the potato beetle southward increases from time to time, as evidenced by reports that reach this Department yearly. Undoubtedly, however, the extreme northern and southern territories which it invades do not become permanent habitats for the insect, the species dying out, mainly because of extremes of cold in the one case and of heat in the other, to be reintroduced in later years when conditions favor its multiplication and spread from other regions.

It has been calculated that it increased its range from its original home to the Atlantic coast at an average annual rate of about 88 miles. Its spread eastward was accomplished largely by flight, as the writer had occasion to observe when a resident of Cleveland in the early days of its invasion of northern Ohio. Great numbers of beetles were seen on bright days in spring and early summer, with outspread wings, being carried directly eastward by the winds.

It has also been disseminated largely by railroads and by lake vessels, and has thus been able, through the direct agency of man, to cross the more barren plains bordering its native confines and the barriers made by large bodies of water. So it will be seen that the winds and waters and eastbound trains have all aided in its dissemination eastward. Riley, from whose works the present account of the early distribution of the insect has been taken, observed the

^a L. c., pp. 36-39.

beetles on Lake Erie in 1870 on various floating objects, and the writer in subsequent years saw the borders of the same lake lined for a foot and more with the hordes of these beetles that had been blown into the water and had then been cast up on the shore.

Beginning with about 1880, it will be noticed, the Colorado beetle appeared in many potato fields of the Gulf region and elsewhere in the South. In certain localities, particularly in Alabama (where it was quite injurious for a time) and South Carolina, this insect seems to have disappeared, and little danger of continuous injury need be anticipated there, as invasions of extreme Lower Austral territory have thus far been merely sporadic appearances. Still, whenever atmospheric conditions favor, the species does temporary damage in such places, only to be killed down again for a number of years, after which the beetles reappear, sometimes invading new localities. It thus will be seen that it would be a somewhat difficult task to outline definitely the permanent distribution of this insect. It is nearly limited, however, as regards severe injuries to the country east of the Rocky Mountains, extending from the Lower Austral to the Transition life zone, and is likely any year to be injurious in extreme portions of this area.

Injuries by this species in the potato section of Aroostook County in northern Maine are well known, and the region there, as well as are portions of Colorado, is credited to the Boreal life zone.^a From recent reports it is fair to say that the species is scarcely a pest at the present day in its original habitat nor in neighboring States, since during the last five years no reports of extensive injuries have been received from Colorado, Kansas,^b Nebraska, or South Dakota. It appears to be firmly established, however, in the States just west of the Mississippi River and from there eastward to Nova Scotia and New Brunswick and southward to the northern portions of the Gulf States.

DISTRIBUTION LIMITED BY EXTREMES OF TEMPERATURE.

Some of the conditions which prevent the too rapid multiplication and permanent establishment of the potato beetle are known. At St. Louis, Mo., it was noticed by Riley that during very hot, dry weather, as in 1868, this insect failed to go through its transformations in the ground, the latter becoming so hot and baked that the pupæ dried out, and the beetle, if it succeeded in throwing off the pupal skin, failed to make its way to the surface. It was also noticed that the larvæ frequently perished under the broiling sun when the ther-

^a These regions may in time be recognized as lying within the Transition zone.

^b Report from Mr. Warren Knaus, dated May 18, 1907, states that this insect has appeared in great numbers in Kansas and threatens serious damage to young crops.

mometer ranged near 100° F. During the intense heat that prevailed during the summer of 1896 the writer noticed the same conditions in and near the District of Columbia, the eggs and larvæ being literally dried up on the potato plants, and the species temporarily disappearing altogether.

Northward the Colorado potato beetle is practically limited to the Transition zone, although it occasionally invades the Boreal zone, as, for example, in Colorado, where it has been found 8,000 or more feet above sea level. Severe winter weather alone probably has little effect upon the insect, since it hibernates, as a rule, exclusively in the beetle state and deep in the ground. It is, moreover, one of our most hardy species, ranking with the hard-shelled snout-beetles in its resistance to cold and frost. Cold snaps, however, overtake the insect before it has sought out proper hibernating quarters, and when these occur it is doubtless killed off in great numbers. As was predicted years ago, the Rocky Mountains have proved an impassable barrier for this species, and the insect has not been able to reach the Pacific coast or neighboring States west of such barrier.

INJURIES, LIFE HISTORY, AND HABITS.

NATURE OF INJURY.

A few remarks in regard to the nature of the injury inflicted by this insect are pertinent. Beetles and larvæ are destructive in nearly equal proportions. In times of its early occurrence east of its original limit this insect not only caused the entire loss of crops, but sometimes destroyed the potato yield of whole counties and of large portions of some States. Indeed, at one time it materially affected the market price of potatoes, not alone by reason of its direct depredations, but in discouraging farmers from the cultivation of the potato on an extensive scale. Thus in 1873 the price per bushel at wholesale in the St. Louis market reached the high figure of \$2. At the present time, fortunately, every progressive grower recognizes the fact that the control of this species is a part of the necessary routine connected with the culture of this tuber.

It was early recognized that the depredations of this insect materially affected the quality of the tuber through the defoliation to which the vines were subjected, and it was at one time difficult to obtain potatoes that were not watery when cooked. This raises the question whether the very marked decrease in quality of potatoes in general at the present day is not due directly to the many years in which the tubers have been deprived of due nourishment by more or less defoliation of the plant itself; for, despite all the remedial measures that are usually practiced, such as the liberal use of arsenicals and "bugging" or jarring, a certain amount of injury nearly

always takes place, which can not fail to affect the tubers when it has occurred practically without intermittence for periods of from twenty to forty years.

FOOD PLANTS.

A wild species of *Solanum* (*rostratum*, and perhaps also *cornutum*) is an original food plant of this potato beetle, and the latter is probably incapable of developing for any number of generations on plants other than those of the potato or nightshade family (*Solanaceæ*). The genus *Solanum* is preferred, and the potato, because of its greater succulence and less acrid taste, is now chosen in preference to plants that grow wild. Still, the insect is nearly always found where its wild food plants grow, particularly where poisons or repellents are used in near-by gardens. It feeds on practically all solanaceous plants, including eggplant, tomato, tobacco, ground cherry (*Physalis*), thorn apple, and Jamestown weed (*Datura*), henbane (*Hyoscyamus*), belladonna, petunia, and pepper. The last is not often attacked, nor are the other plants of different genera from the potato, under ordinary circumstances. Occasionally, when none of these are to be had, the insect will feed on certain weeds and garden plants, among which are cabbage, thistle, and mullein.

It was long ago ascertained that the tender-leaved varieties of potato are most affected, while other kinds, with less tender foliage, such as Peach Blow and Early Rose, are comparatively immune, more particularly when growing in the same field with the preferred variety. Even eggplant seems to be preferred to certain varieties of potato, and is consequently damaged at times, and tomatoes are subject to injury when the foliage of potato is not available.

GENERATIONS.

The normal number of generations of the Colorado potato beetle is evidently two. In fact Tower ^a has observed that this number in both temperate and tropical latitudes is a remarkably constant generic character. In the course of his investigations he has not been able to get the present species to breed more than twice in a season without a period of hibernation or æstivation. Personally the writer has never observed more than two generations in the District of Columbia. Years ago, however, Riley made the positive statement that this species is three-brooded in Missouri,^b and Lugger has made the same statement in regard to its development in Minnesota. Dr. J. B. Smith claims two generations in New Jersey,

^a Loc. cit., p. 243.

^b First Annual Report State Entomologist Missouri, 1869, p. 107.

with sometimes a third partial generation which hibernates in the pupal condition. Considering the fact that this species has invaded new territory and does not live an entirely natural life, having an abundance of food and not being restricted to its single normal plant, it certainly seems possible that a third generation might be produced in an exceptionally warm and humid season, and especially in the most southern localities where it has become established.

LIFE HISTORY.

Hibernation takes place in the beetle stage, under the ground, sometimes to a considerable depth, the beetles having been unearthed from a few inches to several feet beneath the surface. As a rule, however, they do not penetrate deeper than 8 or 10 inches. Exceptionally the beetles winter over in rubbish.

The beetles make their initial appearance quite early in spring, at times issuing from their hibernating quarters soon after the first thaw. At this season they fly readily during the more heated portions of the warmer days, and make aerial journeys of considerable extent. "In flight, the striped elytra are raised and held motionless from the thorax, while the gauzy wings, unfolded and vibrating, strike pleasantly on the eye as the sun intensifies their rosy hues." These flights frequently take place before there are any potato plants for the insect to feed upon, so that as soon as the leaves begin to push their way through the ground the beetles are in readiness for the feast. After a few days of feeding the females deposit their eggs.

The eggs are laid mostly on the under surface of the leaves, and they hatch in from four days to a week or a little later, according to temperature. In from sixteen days to three weeks the larvæ usually attain maturity. They pass through four stages or instars,^a then descend into the earth and undergo transformation to pupæ and subsequently to beetles, in cells which the larvæ form for the purpose. The minimum period of the pupal stage observed at Washington, D. C., in August, 1906, in a very high temperature with corresponding humidity, was seven days. This will be two weeks to a little longer in a lower temperature. The insect is to be found in practically all stages, and particularly as beetles, during the summer months or as long as any solanaceous plants are available as food. It has been learned that the eggs continue developing in the ovaries during a period of about thirty-five or forty days, and it is probable that this species, in common with some others, has the ability of retaining the eggs until a suitable place has been offered for their

^a Observed by Messrs. A. A. Girault and A. H. Rosenfeld at Myrtle, Ga., in May and June, 1906.

deposition. A single female is said to be capable of producing from five hundred to a thousand eggs. Five hundred and twenty-five were observed by Girault and Rosenfeld in the case of one female, laid in masses of from 9 to 53, from May 21 to June 5.

The entire life cycle from egg to adult may be passed in about four weeks. The beetles of the last generation issue early in autumn, feed for another three or four weeks, and then enter the earth for hibernation.

NATURAL ENEMIES.

It has already been stated that atmospheric conditions, with the exception of extreme heat in its more southerly range, are not especially important factors in the repression of this species; hence its fluctuation in numbers, which is noticeable at least locally every season, must be accounted for by the activity of its insect enemies, the numbers of which are legion. Several groups of these enemies are known, each of which contains, as a rule, many species. Among the most important are



FIG. 4.—A ladybird (*Hippodamia convergens*) which preys on the Colorado potato beetle. Enlarged (author's illustration).

ladybirds,^a many common species of which, in both their larval and adult stages, prey upon the potato beetle, destroying great numbers of its eggs and young larvæ. One of the commonest of these ladybirds is illustrated for comparison with the Colorado beetle by figure 4.

Several ground-beetles,^b also of predaceous habits, attack and devour the larvæ of this potato beetle, and of these the so-called great Lebia (*Lebia grandis* Hentz, fig. 5) is particularly attached to this species, following it wherever it goes and doing perhaps more effective service than any single natural enemy of which we have knowledge. Several soldier-bugs also attack it, one of which, the spined soldier-



FIG. 5.—*Lebia grandis*, an important potato-beetle enemy. Enlarged (Marx, del.).

^a The ladybird enemies of this species are: *Coccinella 9-notata* Hbst., *C. sanguinea* L., *Megilla maculata* DeG., *Hippodamia convergens* Guér., *H. 13-punctata* L., *H. glacialis* Fab., *Anatis 15-punctata* Ol. (*ocellata*), and *Chilocorus bivulnerus* Muls.

^b Carabid enemies include the great Lebia (*Lebia grandis* Hentz), the fiery ground beetle (*Calosoma calidum* Fab.), *Pasimachus clongatus* Lec., *Harpalus caliginosus* Fab., *Lebia atriventris* Say, and *Brachynus kansanus* Lec.

bug,^a is illustrated at figure 6. Other natural enemies are robber flies,^b spiders, and a tachina fly.^c This last develops within the body of the potato beetle larva and has been observed so abundant in potato fields that its buzzing resembled the noise made by the swarming of bees. Wasps of some species attack the larvæ, and the rust-red social wasp^d has been seen carrying them to provision its nest. Not infrequently the beetle is found partly covered by dull, yellowish, rounded mites. These are external parasites^e and help somewhat in reducing their hosts. A species of daddy-long-legs is also a natural enemy.^f

Other predatory insects include a tiger beetle (*Tetracha virginica* L.) and two rove-beetles (*Philonthus apicalis* Say and *Quedius molo-chinus* Grav.). Most of the species listed above have been recorded by Riley, but many have also been observed independently by others, and correspondents of this Bureau frequently call attention to the commoner forms.

Thus far only insect foes of the potato beetle have been discussed, but certain mammals, birds, amphibians or batrachians, and reptiles are well-known enemies. One of the most important of the birds is the rose-breasted

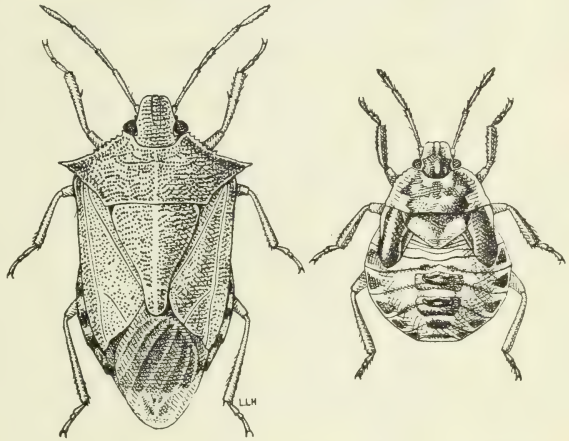


FIG. 6.—The spined soldier-bug (*Podisus maculiventris*): Adult at left, nymph at right. Much enlarged (original).

grosbeak, whose services as an enemy of this beetle have been little appreciated until comparatively recent times. The bobwhite or quail^g

^a The soldier-bugs include *Podisus maculiventris* Say [*spinosus*], *P. cynicus* Say, the bordered soldier-bug (*Stiretrus anchorago* Fab., *Perillus circumcinctus* Stål., *P. claudus* Say, *Milyas cinctus* Fab., and *Sinea diadema* Fab. These commonly attack the larval potato beetle. *Nezara hilaris* Say and *Euschistus variolarius* Beauv. are said to have the same habit, but can not be important enemies, as they are naturally herbivorous.

^b *Proctacanthus milbertii* Macq.

^c *Phorocera* (*Lydella*) *doryphoræ* Riley.

^d *Polistes rubiginosus* Lep. *P. pallipes* Lep. is said to have the same habit.

^e The most abundant of these is *Uropoda americana* Riley.

^f *Liobunum* (*Phalangium*) *dorsatum* Say.

^g This bird is one of the most important enemies of an equally destructive species, the chinch bug.

also does excellent service and destroys many. Other birds which are known to eat the potato beetle, on the authority of the Biological Survey, are the following: Ruffed grouse, nighthawk, cuckoo, scarlet tanager, the wood, hermit, and olive-backed thrushes, and robin. The crow not only picks beetles from the vines, but digs them from the earth. The cardinal is a well-known potato-beetle destroyer, and even the English sparrow has been seen to eat them.

Domestic fowls are of some assistance in destroying this pest, and of these the duck early took to this insect, which is distasteful to some other fowls. For some time after the spread of the Colorado beetle to new territory chickens did not attack it, presumably because it has, in common with many other leaf-beetles, a nauseous taste. For several years, indeed, it was believed to be actually poisonous. After a time, however, chickens became better acquainted with this insect and began devouring its eggs and afterwards the larvæ, finally eating the beetles with apparent relish. Skunks and snakes are reported to eat the beetles, and toads frequently gorge on them.

METHODS OF CONTROL.

This species is not a difficult one to control, no other method being necessary for its destruction than the free use of an arsenical or mechanical means. Before taking up the remedies that may be most profitably employed, it may be well to preface with the statement that an arsenical liquid *spray* is preferred, and that dry arsenicals, hand-picking, and jarring are practicable only on a small scale where the grower has no spraying outfit, and occasionally when infestation is slight and limited to a small area. Every market gardener should be equipped with a *good* spraying outfit.

MECHANICAL METHODS.

Jarring, if employed early in the season, is of considerable value. It is a time-worn remedy and so well known as scarcely to need description. It is customary in many localities to gather the beetles and their larvæ in pans containing a little water on which a very thin scum of kerosene is floating. Large shallow milk pans are excellent for this purpose. At the same time the egg masses should be picked where seen. Numerous appliances have been invented and some patented for destroying this pest, but the arsenicals are so effective that other remedies are really not necessary.

Brushing.—The susceptibility of potato-beetle larvæ to extreme heat, as has already been recounted, indicates that a remedy much in vogue against the asparagus beetle, namely, the mere brushing of the larvæ from the plants on an extremely hot and dry day, will be effect-

ive. So far as the writer knows, however, this has never been given a thorough trial for the potato beetle. It should be tested.

Fall and spring plowing are of value in a general way, as for other insects which pass the winter in the earth, but they are by no means perfect measures, as the beetles are hardy and not much affected by this treatment.

ARSENICALS.

Arsenicals are the best remedies for the Colorado potato beetle, and on small potato patches Paris green is usually applied dry, mixed with flour; but, as previously stated, it is best used as a spray. Where early hand methods have been employed, thorough treatment with an arsenical should follow.

Paris green, dry.—When applied dry, Paris green is mixed with from 10 to 20 parts of cheap dry flour, sifted land plaster, or fresh air-slaked lime. This remedy affords best results early in the season on young plants. It should be dusted on preferably when the dew is on and by means of powder guns or bellows, or the so-called "dust-spray" machines, so as to cover the plants and leave as little surface as possible for food for the first-appearing beetles. In spite of this, however, some beetles will succeed in depositing their eggs on the lower surface, which is difficult to reach with a dry mixture, and when the larvæ hatch another application must be made. In fact this remedy must be used for some time or until the plants obtain a fair growth, when spraying will be found more effective.

The Paris green spray is prepared by mixing the arsenical with water or Bordeaux mixture^a at the rate of 1 pound of poison to 75 to 125 gallons of the diluent. If water alone is used, quicklime in about the same proportion as the poison should be added to prevent scorching. For the proper mixing and application of this spray a bucket pump or knapsack sprayer of good quality is sufficient for use in small gardens, but on a larger scale a potato sprayer to be drawn by one or two horses through the rows of plants is necessary. With the latter, from two to six rows can be treated at a time. Special four and six row potato sprayers are on the market. The Paris green should be mixed with a small quantity of water into a thin paste before the bulk of water is added and should then be thoroughly blended by churning in the force pump or sprayer. The mixture, being a mechanical one, is not constant, and the Paris green will sink to the bottom. To avoid this it must be stirred constantly while being applied. It is advisable to use the Bordeaux mixture as a diluent, as this is a valuable insect repellent as well as a standard

^a Directions for the preparation of this fungicide and the arsenicals here discussed are given in Farmers' Bulletin 127, U. S. Department of Agriculture, which can be obtained on application to this office.

fungicide, and it operates also against different forms of blight and other diseases which may threaten the crop.

Arsenate of lead serves the same purpose as Paris green, and for use against the Colorado potato beetle is still more valuable. Complaints have been made that several applications of Paris green are necessary during the season, and extra doses are required after each rain. Arsenate of lead is applied in practically the same manner as Paris green, but it contains less poisonous arsenical (60 to 70 per cent when dry), and being sold usually in the form of a paste it is used at a considerably greater strength—i. e., about 1 pound combined with 15 to 25 gallons of water or Bordeaux mixture. Being more adhesive, it adheres more firmly to the leafage and is much less likely to produce scorching.^a Its adhesiveness is still more enhanced by the addition of about the same amount, by weight, of resin fish-oil soap as of the arsenical used.

The number of sprayings to be applied will depend somewhat upon local and seasonal conditions. Two or three will ordinarily suffice for the spring brood, especially if applied just after the eggs have hatched, and the same number should be applied for the second generation.

Other arsenicals may be used if preferred. Among these are arsenite of lime with soda, which has the merit of being as efficient as Paris green and lime and far cheaper. It is not on sale at the present time ready made, like arsenate of lead. Scheele's green, similar to Paris green, is employed in the same way as the latter.

Summary.—To sum up the directions for the use of arsenicals, it should be said that arsenate of lead, because it can be purchased already combined, in paste form, which is preferable, takes first place, in the writer's opinion, as a potato-beetle insecticide. The mixture of Paris green, lime, and water is in nearly the same class, because the ingredients can be purchased anywhere. The dry Paris green mixed with air-slaked lime properly comes last, as it is less effective than the other mixtures and much of the material is wasted.

Precautions to prevent poisoning.—In the use of arsenicals, as well as other poisons, care should always be taken to avoid accident. This can be best accomplished by plainly marking the contents on all receptacles, such as bottles or packages, in which the poison is kept. In addition a "POISON" label, which can be obtained of any druggist, should be affixed. It is best also to keep such substances under lock and key. The utensils employed in the preparation of the mixtures which have been discussed should be thoroughly cleaned after use.

^a In point of fact it can be used at the rate of 1 pound to 10 gallons without injury, but this proportion is not advisable, owing to the extra cost, and scorching would be apt to follow its use on plants exposed to hot sunlight.

ERADICATION OF WEEDS AND COOPERATION.

It is always wisdom on the part of the agriculturist to keep down the weeds on the farm, and in the treatment of the present insect if those weeds which are known to furnish it with food, such as sand-bur and Jamestown weed, were cut just before seeding, it would prevent the overdevelopment of the pest and of other insects which feed on the weeds, as well as the weeds themselves. The farmer should familiarize himself with the wild food plants of this pest.

Keeping the potato patch and, in fact, the entire farm as free as possible from solanaceous weeds should be practiced by all farmers of a neighborhood, and if the potato grower could secure the cooperation of his neighbors in the use of an arsenical spray, and would also destroy the insects by spraying infested wild food plants, the effect would soon be noticeable, as there can be no doubt that the species would soon be reduced to small numbers, at least in limited areas, if this cooperation were thorough and persistent. This statement is based on the fact that the beetles are seldom if ever seen migrating nowadays in any such numbers as in earlier years, and there is not therefore the constant danger of reinfestation from a distance as was formerly the case. There may, of course, be occasional exceptions.

Finally, as a general proposition, the potato grower should keep his potatoes free from diseases, such as wilt and scab, and spray for flea-beetles and any other insects which may be found in addition to the Colorado beetle. He should also pay particular attention to the methods of growing best adapted for his location. Information in regard to the methods of potato culture is furnished in Farmers' Bulletin No. 35, U. S. Department of Agriculture, and potato diseases and their treatment are considered in Farmers' Bulletin No. 91. Both of these publications can be had on application to the Secretary of Agriculture.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *April 10, 1907.*

[Cir. 87]

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE TERRAPIN SCALE.

(*Eulecanium nigrofasciatum* Pergande.)

By J. G. SANDERS, Assistant.

From every State east of the Mississippi River, and from Missouri, Arkansas, Louisiana, Texas, Minnesota, and the Province of Ontario, Canada, the terrapin scale has been reported and authentic specimens have been received by this Office. It is noteworthy that this species of scale, more conspicuously marked than any other of the genus, is the most generally injurious one. In consequence of its wide range of food plants, including both wild and cultivated trees, it must be considered a dangerous pest, which may be controlled but never eradicated.

This scale insect can be recognized and identified especially well in the hibernating winter stage (fig. 1), when it appears as a reddish hemispherical scale 2 mm. in length, mottled with radiating streaks of black which are especially conspicuous about the margin. Sometimes these radiating streaks coalesce, forming a subdorsal dark band surrounding the central reddish boss. Occasionally individuals are found which are entirely red or black.

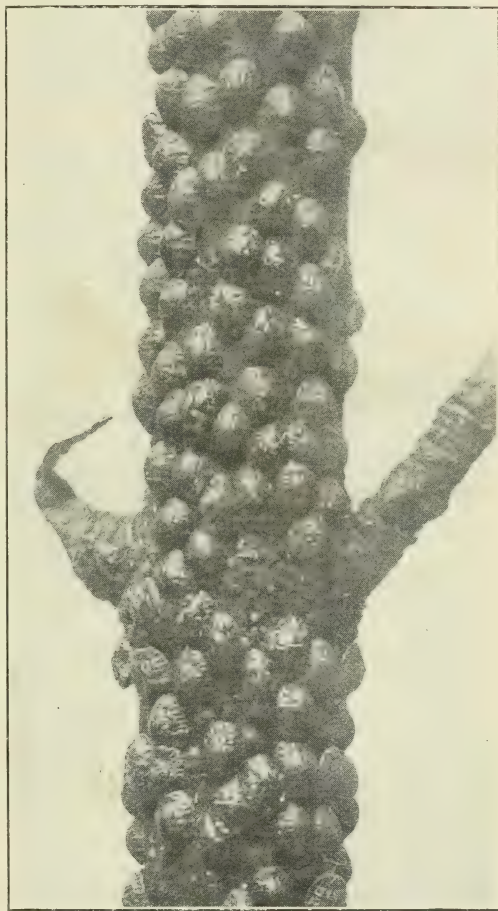


FIG. 1.—Terrapin scale (*Eulecanium nigrofasciatum*). Adult females on twig of peach. Enlarged about three times (original).

Although this species was not described until 1898,^a the describer, Mr. Theodore Pergande, of this Office, had known it since 1872, when it was found upon peach trees at Hillsboro, Mo.

FOOD PLANTS.

For many years the terrapin scale has been considered a specific enemy of the peach and has been confounded by many entomologists and others with *Eulecanium persicæ* (Fab.), the preeminent peach soft scale of Europe. At present we know it as infesting a large number of host plants, including many varieties of peach and cultivated plum; various species of wild plums and cherries; *Prunus simonii*; apple; pear; quince; several species of *Cratægus*; three species of maple, particularly *Acer saccharinum*; oriental and western sycamores; Carolina poplar; olive; blueberry (*Vaccinium* sp.); Bumelia, and spice bush (*Benzoin benzoin*).

DESCRIPTION.

The following technical description is inserted to facilitate the determination of this species by entomologists, or anyone who may have access to a compound microscope.

Adult female (fig. 2).—Nearly hemispherical, small, length 3 to 3.5 mm., exhibiting many of the superficial characters of the hibernating form described above, though showing a tendency to fade rapidly after oviposition until by the autumn she is plain dull yellow or terra-cotta color. Fresh unrubbed specimens are covered by a thin glassy secretion of wax which scales off readily. When cleared by boiling in a solution of potassium hydroxid, the derm is left quite colorless, excepting the brown chitinated anal lobes and a narrow chitinated area surrounding the lobes. Antennæ (fig. 3, *b*) composed of six segments; segment 3, which occasionally shows a pseudo-joint, is equal in length to 4, 5, and 6 together; next in order of length come segments 2 and 1 in order. The antennæ exhibit the ordinary chaetotaxy. Legs well developed; tibia slightly longer than tarsus, bearing a pair of long, knobbed tarsal digitules and a pair of long expanded unguis. There are irregular rows of

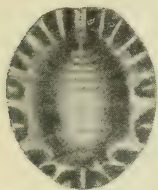


FIG. 2.—Terrapin scale (*Eulecanium nigrofasciatum*): Adult female. Enlarged (after Pergande).

many pores leading from the spiracles to the spiracular spines (fig. 3, *c*) on the margin of the body. The median spiracular spine of each group is robust and about 50 mm. long, three times the length of the two shorter spines; marginal spines (fig. 3, *d*) slender, about equidistant, except four, which are closely crowded at the anterior median point.

The distinguishing microscopical characteristic of this species is the irregular single or double mid-dorsal row of 25 to 40 low, subconical appendages (fig. 3, *e*), appearing like pores, extending from near the anal lobes to nearly above the sucking mouthparts. These pores are usually quite evident in a mounted specimen and serve to separate this species surely from all others. The thick anal plates (fig. 3, *a*) are quite symmetrical, somewhat longer than broad, with the posterior lateral margin rounded and thickened. Each plate bears two minute apical and two subapical

^a Bul. 18, n. s., Div. Ent., U. S. Dept. Agric., pp. 26-29.

onger setæ. There are four fringe setæ, the inner pair about one-half the size of the outer pair.

Male.—The male of this species is a minute, delicate, two-winged insect which appears about August 1. The filmy, iridescent wings have an expanse of about 4 mm. The body is rose-red, with some dark markings and a heavy brown thoracic band.

This species should not be confounded with *Eulecanium prunastri* (Fonse.), a small, very convex, dark-red, shining species, which has a group of many (200 to 300) pores with interspersed spines, extending from the anal lobes to near the anterior margin; the spiracular spines are nearly uniform in length, being scarcely longer than the marginal spines. The latter species was first recorded from the United States in November, 1894, when it was sent to this Office from Columbia, Pa., on plum twigs. Europe is its original home, whence it must have been exported to the United States on nursery stock or cuttings.

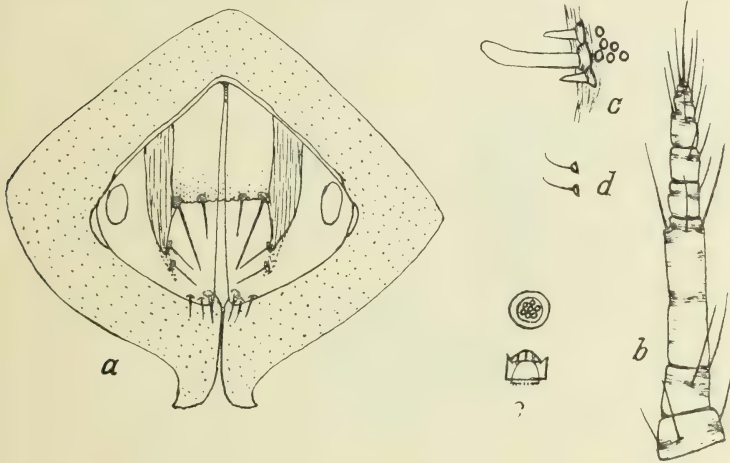


FIG. 3.—Terrapin scale (*Eulecanium nigrofasciatum*): a, Anal lobes and surrounding chitinous area; b, antenna; c, spiracular spines; d, marginal spines; e, conical, compound pore. All greatly enlarged (original).

PARASITES.

Very small, parasitic four-winged flies of the genus *Coccophagus*, family Chalcididae, are our greatest benefactors in the control of this scale insect.

REMEDIES.

Unfortunately the lime-sulphur wash, which is such an excellent remedy for the San Jose scale and which at the same time controls the peach leaf-curl, is worthless for treating the terrapin scale. Numerous experiments in the use of the lime-sulphur wash against this scale on various host plants have produced only negative results.

Kerosene emulsion has proved to be the most effective remedy for the control of this pest. This emulsion, when properly made according to the formula below, can be sprayed with safety on any tree during the dormant period—in winter or early spring before the buds open—at a strength of 20 to 25 per cent. A nozzle throwing a fine spray should be used. Care should always be exercised to prevent the liquid from running down the trunk of the tree and collecting about the roots, as the oil, which will be retained by the soil around the roots for an indefinite period, might seriously injure or kill the tree.

KEROSENE EMULSION.

Stock solution (66 per cent oil).

Kerosene (coal-oil, lamp-oil)	gallons. 2
Whale-oil or laundry soap (or 1 quart soft soap)	pound. 1
Water	gallon. 1

Dissolve the soap in boiling water, *then remove from the fire*, add the kerosene immediately and thoroughly agitate the mixture until a creamy solution is obtained. This can be done by pouring the mixture into the tank of a spray-pump and pumping the liquid through the nozzle back into the tank. This is a stock solution which must be diluted before using. In order to make a 20 per cent emulsion, add to each gallon of the stock solution about $2\frac{1}{3}$ gallons of water and agitate thoroughly before using. For a 25 per cent solution add to each gallon of the stock solution $1\frac{2}{3}$ gallons of water and agitate thoroughly. This strength will kill a large percentage of the hibernating females, without injury to the trees.

If a good naphtha soap can be obtained the preparation of the emulsion will be simplified. It will be unnecessary to heat the solution, since the kerosene will combine readily with the naphtha and soap and form a perfect, cold, milky-white emulsion when the mixture is thoroughly agitated. If naphtha soap is used, double the amount called for by the formula, and emulsify in soft (rain) water.

Approved:

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., April 3, 1907.

[Cir. 88]

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE PERIODICAL CICADA IN 1907.

(*Tibicen septendecim* L., race *tredecim* Walsh-Riley.)

By C. L. MARLATT,

Entomologist and Acting Chief in Absence of Chief.

This is a circular of inquiry concerning the brood of the periodical cicada or "locust" (fig. 1) which will occur in May and June of this year throughout the Southern States east of Texas, except Florida, northward to the Mississippi and Ohio valleys through Missouri to southeastern Iowa, and over most of central and southern Illinois and extreme southwestern Indiana. This brood covers also western Kentucky and more or less of Tennessee, with extensions northeastward across the Carolinas into Virginia. A doubtful record is known from the Rio Grande in the region of El Paso, Tex., but no other records have been obtained for this State, and the El Paso record is therefore open to some question.

The Bureau of Entomology wishes to obtain a complete record of the distribution of this important brood this year, and therefore a reply card is sent with this circular, on which the information relating to its occurrence in each district may be indicated. It is hoped that every recipient of this circular and reply card will keep the matter in mind, fill out the card as indicated, and return it to this office. *A negative record is often quite as valuable as one of actual occurrence.* The card should be filled out with the name of the locality, including the State, county, and town, the name of the observer, and the date. Space is left at the bottom of the card for a note on any features of interest, and the information given should include the date of first appearance or emergence of the cicada, the date of its general disappearance, and the

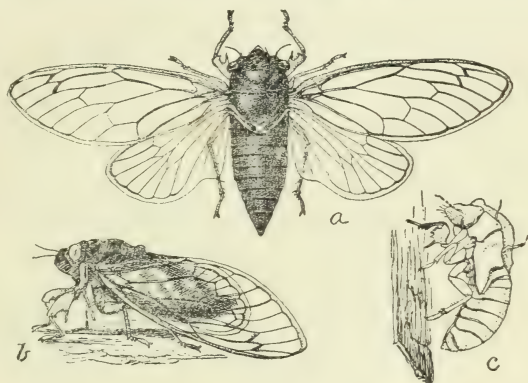


FIG. 1.—The periodical cicada (*Tibicen septendecim*): a, adult; b, same, side view; c, shed pupal skin. Natural size (author's illustration).

numbers—in other words, whether very numerous or scattering, or whether only a few individuals occur. No postage is necessary on this card.

The cicadas or “locusts” will appear between the middle and end of May—later in the northern range of the brood and perhaps a little earlier in the southern range. Records of scattering occurrence after the middle of June may apply to other species of cicadas which occur every year, and in any doubtful case it will be just as well to send specimens for determination.

It is especially desirable to have the wooded river bottoms of southeastern Texas and of the Rio Grande examined for the possible occurrence of this insect, and also Indian Territory, Oklahoma, and southeastern Kansas, to determine more accurately than is now known the western limits of this brood.

The brood of this year is the largest of the thirteen-year broods of this curious insect. The first record of it relates to its occurrence in 1803, and it has been recorded at every thirteen-year period since that year to the date of last appearance, in 1894. A great many records have already been obtained on the various years when it appeared, and notably on the last three return periods; but in all the recent instances when it has been studied carefully it has come in conjunction with some brood of the northern seventeen-year race, and there has been some overlapping of territory. Necessarily, therefore, there exists some uncertainty as to the records falling in territory covered by both races. In 1907 this thirteen-year brood will occur without any northern or seventeen-year brood, and all of the records can probably be safely assigned to the former, so that it should be possible this year to clear up any uncertainty as to distribution.

The accompanying map (fig. 2) showing the distribution of the brood is the one published in Bulletin No. 14, which gives a general account of the periodical cicada. Since the publication of this bulletin a good many new records not indicated on the map have been obtained for this brood. All the State and county occurrences now recorded are given in the list below. The map, however, indicates the substantial distribution, as most of the new records fall within those plotted on the map.

Its present limits are as follows:

Alabama.—Autauga, Blount, Bullock, Cherokee, Colbert, Cullman, Dallas, Dekalb, Elmore, Etowah, Franklin, Hale, Jackson, Jefferson, Lamar, Lauderdale, Lowndes, Macon, Marengo, Mobile, Montgomery, Perry, Randolph, Russell, St. Clair.

Arkansas.—Baxter, Benton, Boone, Carroll, Clark, Clay, Conway, Crawford, Drew, Franklin, Fulton, Garland, Grant, Greene, Hempstead, Hot Spring, Iard, Johnson, Lawrence, Logan, Lonoke, Madison, Marion, Newton, Prairie, Pulaski, Randolph, Searcy, Sebastian, Sharp, Stone, Van Buren, Washington, White.

Georgia.—Campbell, Catoosa, Chattooga, Cherokee, Fulton, Harris, Houston, Pike, Rabun, Richmond, Walker.

Illinois.—Adams, Bond, Cass, Champaign, Christian, Clark, Clay, Clinton, Coles, Crawford, Cumberland, Douglas, Edgar, Edwards, Effingham, Franklin, Gallatin, Greene, Hamilton, Hancock, Hardin, Iroquois, Jasper, Jefferson, Jersey, Johnson, Lawrence, Livingston, McLean, Macon, Macoupin, Madison, Marion, Massac, Monroe, Montgomery, Morgan, Perry, Piatt, Pike, Pope, Randolph, Richland, St. Clair, Saline, Sangamon, Scott, Shelby, Union, Vermilion, Wabash, Washington, Wayne, White, Williamson.

Indiana.—Vanderburg.

Indian Territory.—Choctaw, Creek.

Iowa.—Lee.

Kentucky.—Carlisle, Graves, Lyon, McCracken, Marshall.

Louisiana.—Bossier, Caddo, Claiborne, Morehouse, Washington.

Mississippi.—Attala, Carroll, Clarke, Copiah, Franklin, Jasper, Lauderdale, Leake, Madison, Monroe, Oktibbeha, Webster.

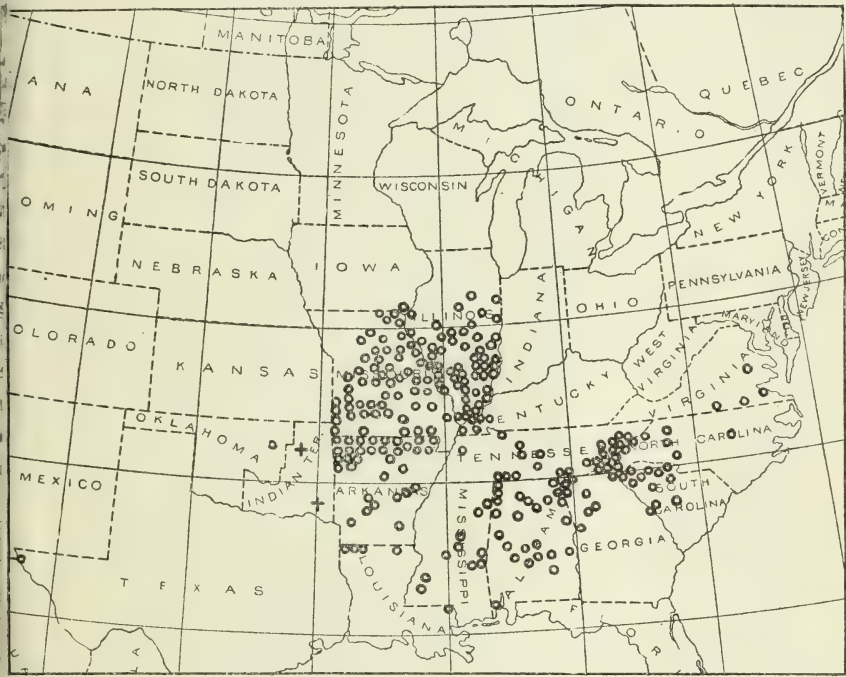


FIG. 2.—Map showing distribution of Brood XIX, 1907.

Missouri.—Audrain, Barry, Barton, Benton, Bollinger, Boone, Butler, Callaway, Cedar, Chariton, Clark, Cole, Cooper, Dade, Dallas, Douglas, Franklin, Gasconade, Greene, Henry, Howard, Iron, Jasper, Jefferson, Knox, Laclede, Lawrence, Lewis, Linn, Livingston, McDonald, Macon, Madison, Marion, Moniteau, Monroe, Morgan, Newton, Oregon, Pettis, Phelps, Pike, Polk, Pulaski, Ralls, Randolph, Ripley, St. Charles, St. Clair, St. Francois, St. Louis, Saline, Schuyler, Scotland, Shannon, Stoddard, Stone, Warren, Washington, Webster, Wright.

North Carolina.—Caldwell, Cherokee, Clay, Davie, Graham, Granville, Haywood, Iredell, Macon, Madison, Mecklenburg, Moore, Swain, Wake, Wilkes.

Oklahoma Territory.—Payne.

South Carolina.—Aiken, Anderson, Chester, Greenville, Laurens, Oconee, Orangeburg, Pickens, Spartanburg, Union, York.

Tennessee.—Bedford, Blount, Cocke, Davidson, Gibson, Giles, Greene, Hamblen, Hamilton, Hickman (?), Jefferson, Knox, Lawrence, McMinn, Marshall, Monroe, Montgomery, Rutherford, Sevier, Stewart, Wayne, Williamson, Wills. *Texas*.—El Paso (?).

Virginia.—Brunswick, Halifax, Hanover, Prince George.



FIG. 3.—Egg punctures of the periodical cicada: *a*, twig showing recent punctures, from front and side, and illustrating manner of breaking; *b*, twig showing older punctures, with retraction of bark and more fully displaying the arrangement of fibers. Natural size (after Riley).

GENERAL CONSIDERATIONS.

The periodical cicada is so well known that a general account of it in this place is unnecessary. When it appears in great numbers it naturally causes considerable alarm and arouses fears for the safety of shade trees and orchards. The actual damage, however, is usually slight, except in the case of newly planted orchards, and even here, by vigorous pruning back after the cicada has disappeared, much of the injury caused by the egg punctures (fig. 3) can be obviated.

Ordinary repellent substances, such as kerosene emulsion or carbolic acid solutions, seem to have very little effect in preventing the oviposition of these insects. Some recent experience, however, indicates that trees thoroughly sprayed with Bordeaux mixture or a lime wash are apt to be avoided by the cicada, especially if there are other trees or woods in the neighborhood on which they can oviposit. The most reliable means of protecting nurseries and young orchards is by collecting the insects in bags or umbrellas from the trees in early morning or late evening, when they are somewhat torpid. Such collections should be undertaken at the first appearance of the cicada and repeated each day.

It is hoped that everyone who receives this circular will keep a sharp lookout for swarms of this brood of cicadas and assist the Bureau in fixing its range accurately by sending explanatory information.

Approved:

JAMES WILSON, *Secretary of Agriculture*.

WASHINGTON, D. C., April 23, 1907.

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE WHITE-PINE WEEVIL.¹

By A. D. HOPKINS,

In Charge of Forest Insect Investigations.

The Bureau of Entomology has been conducting systematic and economic investigations of the weevils infesting the bark of the trunk and terminal shoots of conifers in the United States, the results of which will be published in the regular technical and popular bulletins; but since



FIG. 1.—White-pine weevil (*Pissodes strobi*): *a*, Adult, smaller figure natural size; *b*, larva, line at left natural length; *c*, pupa, small figure of adult showing natural size. (Original.)

These can not be issued in time to be of service this season, this circular has been prepared to give the information which is of immediate practical importance in regard to one of the most destructive of these weevils.

THE INSECT AND ITS HABITS.

The white-pine weevil is a somewhat elongate, brownish snout beetle, to 5 mm. in length, having the thorax and elytra marked with irregular spots of brown and white scales (fig. 1, *a*). The winter is passed in the adult stage, evidently in the ground. The beetles come out of their winter quarters and fly early in May, and after feeding for a few days on the bark of the living white-pine terminal shoots deposit their

¹ *Pissodes strobi* Peck; Order Coleoptera, Family Curculionidae.

eggs in punctures in the bark of the shoot of the previous year's growth, placing one or two eggs in a pit or cavity in the inner bark made by

the beak of the mother beetle. In from six to ten days the eggs begin to hatch into small white grubs (larvæ), which at first are usually found in large numbers feeding upon the inner bark and cambium (see fig. 2). They usually work downward and sometimes extend their work into the bark of the 2-year-old stem and base of the branches. By the time the larvæ have completed their development (fig. 1, *b*) they are greatly reduced in numbers by natural enemies and other causes. The survivors burrow into the wood or pith of the terminal and excavate individual transformation cells, which they line and cover with excelsior-like borings. In these cells they transform to pupæ (see fig. 1, *c*) and adults, and during July and August of the same year, when the adults are fully matured, they bore their way out and seek suitable places in which to pass the winter.

LONG LIFE OF THE ADULT.

From recorded observations on some species of *Pissodes* or bark weevils by investigators in Europe, and on representatives of other allied forms in Europe and in this country, it appears that an individual adult may live two or three years and will deposit eggs each year.

SEASONAL HISTORY.

FIG. 2.—White-pine weevil: Newly hatched larvæ at work in vigorous terminal shoot of white pine. (Author's illustration.)



The beetles are active from about the 1st to the 15th of May or later, depending on local conditions and weather. Eggs are evidently deposited during the principal activity of the adults, possibly during the greater part of the month of May. The

ders of dense stands wherever the soil and other conditions are most favorable for rapid growth.

The unfavorable conditions for injury are slow growth, dense pure stands, and mixed stands of pine and hardwood.

Under the former conditions the thrifty, vigorous terminals are especially favored as breeding places for the weevil; and where these are killed, the vital energy of the tree is thrown into the lateral branches. Open stands, therefore, favor the development of large branches and a spreading crown, while under conditions unfavorable to weevil injury the terminals are smaller and, even if they are killed, the close stand or lateral shade will tend to produce an upward or vertical growth of the topmost branches, the stronger one taking the lead and soon repairing the damage.

NATURAL ENEMIES.

Numerous parasitic and predatory insect enemies attack the developing broods in the terminals. Woodpeckers, also, feed on the matured

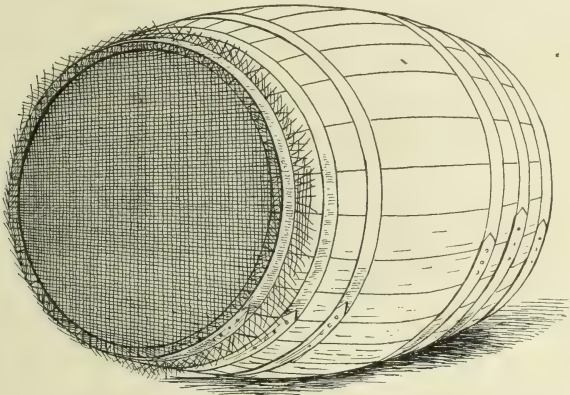


FIG. 6.—Barrel for terminal shoots infested by white-pine weevil, with wire screen over end allowing escape of parasites but preventing escape of weevils. (Original.)

larvæ, pupæ, and adults. Some of the larvæ apparently die from disease, and when large numbers of them are crowded together the larger ones appear to feed on the smaller ones, so that on the average not more than from 3 to 5 per cent of the hatched larvæ ever reach maturity and emerge from the infested terminals. However, each female is capable of depositing more than one hundred eggs each year for several years; thus the depredations are continuous. During some years the damage will be slight, while in other years it will be very severe, the amount of injury depending on the number of adults that survive and the conditions presented for their attack and development.

METHODS OF CONTROL.

It will be seen that in the successful control of this pest, as in the control of forest insects in general, much depends on special features in

the general methods of forest management which will bring about unfavorable conditions for injury and thus prevent loss.

It will also be seen how important it is to know the principal facts in regard to the life history and habits of the insect, in order to secure the best results from methods of management and of direct control.

Heretofore this species has been confused with another species with very different habits, and some of the published data and recommendations based on such confusions are of no value.

The white-pine weevil rarely, if ever, passes the winter in the terminals. The present evidence indicates that it never breeds in the thin bark on the trunks and stumps of the white pine or other pines; that it can not be trapped in the trunks of felled and girdled pine.

DESTRUCTION OF THE BROODS.

The only practical method of destroying the weevil appears to be the treatment of the infested terminals, and to secure the best results special attention must be given to certain important details.

If the infested terminals are cut or broken during June and July and burned, the broods of the weevil will be effectually destroyed, but vast numbers of natural enemies will also be destroyed. A better method is to collect the terminals during the first half of July before the beetles begin to emerge and to place them in tight barrels securely covered with wire fly-screen netting on one or both ends (see fig. 6). The barrels should be left in the groves, so that the parasites and other enemies may escape, while the beetles perish. After the 1st of October the weevils will all be dead, and the netting may then be removed, although the barrels with their contents should be left until the following June to allow the escape of the later developing and larger parasites. The barrel should not be placed in a position to collect rain. It is necessary, however, if this method be adopted, that it be repeated two or three years in succession in the same locality, in order to catch the successive broods from the old parent beetles that live over from preceding years.

NOTE.

The statements and recommendations in this circular are based on recent observations and investigations by the author and by Field Assistant W. F. Fiske and serve as a partial revision of what has hitherto been published.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., May 21, 1907.

United States Department of Agriculture, BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

NOTE ON THE OCCURRENCE OF THE NORTH AMERICAN FEVER TICK ON SHEEP.

By W. D. HUNTER,

In Charge of Cotton Boll Weevil Investigations.

There are no published records of the finding of specimens of the North American fever tick (*Boophilus annulatus* Say) on sheep. In fact, it has generally been supposed that this species does not occur on sheep, although Mr. B. H. Ransom has surmised that such might be the case.¹ In connection with the tick work of the Bureau of Entomology an agent, Mr. J. D. Mitchell, has recently obtained data which indicate a rather general occurrence of the fever tick on sheep. On account of the considerable practical importance of this matter it is thought advisable to publish this preliminary note.

The practical importance of the discovery made by Mr. Mitchell lies in the fact that the dissemination of ticks by sheep may play a very important part in the work of eradication that is now under way. In the general work of the eradication frequent use must be made of the "starvation" plan under which the cattle are removed from pastures for a considerable time. In many parts of the tick-infested area most of the cattle raisers have as many cattle as they can possibly carry on their holdings. To be forced to dispense with the use of a part of the pasture area in many cases would force the sale of a portion of the cattle, perhaps at an unfavorable time for marketing. If, however, it were possible to allow some other kind of live stock to graze on pastures from which ticks are being eradicated according to the starvation plan, the inconvenience and possible loss to the ranchmen would be considerably lessened. Since the North American fever tick has previously not been known to infest sheep, it has been thought that the pastures might be used for grazing these animals. The discoveries made by Mr. Mitchell, however, indicate that the dissemination of fever ticks by sheep is of such practical importance that, at least in the parts of Texas where the matter has been investigated, a pasture would remain infested indefinitely even if the sheep alone were allowed to roam over it. It is not a case of the scattering of the seed ticks from one part of the pasture

¹ Cir. 98, Bureau of Animal Industry, U. S. Dept. Agric., p. 8, October, 1906.

to another, but a case of the breeding of the fever ticks on sheep, since in several cases fully engorged females have been found on these animals, and they are now freely depositing eggs.

The following are some of the particulars regarding data obtained up to this time. The matter will be followed up by the Bureau of Entomology, and a further report will be made at the end of the season.

In April, 1907, Mr. A. P. Ward, of Jackson County, Tex., sent to Mr. J. D. Mitchell a number of specimens of *Boophilus annulatus* that he had taken from a sheep. In this lot there was one engorged female that deposited eggs which have hatched. Mr. Ward's attention was attracted to the matter by seeing this tick hanging in the hair of one fore leg. It was in the act of dropping to the ground for oviposition. At least a dozen other specimens were then collected on this animal. There were five or six nearly engorged adult females, together with several nymphs and larvæ. The sheep upon which these ticks were found had not been sheared this season, although the wool was rather scant on the belly. Nevertheless, the ticks had made their way well up into the thick wool on the sides of the animal. Mr. Ward notes that the sheep was "as oily as she could be." The animal was one which had been left in an isolated field for a month before the ticks were discovered. In moving the herd this one had accidentally been left behind. She was exceedingly active, and there were no indications whatever of any disease. The only fact which would tend to indicate the possibility of disease in this sheep transmitted by the ticks is that she remained in the same place after the herd was removed. It is barely possible that she was left behind on account of weakness brought about by the disease at the time the herd was removed. However, subsequent evidence from other flocks fails to justify the assumption that there may have been any disease in this case.

Early in May, 1907, Mr. J. D. Mitchell examined many sheep in the flock belonging to Mr. Ward. One adult female tick was found, together with six individuals just passing from the nymphal to the adult stage. These were on several different animals, but all located in the ears.

At about the same time three sheep in a flock in Calhoun County were examined by Mr. Mitchell. Two adult female ticks about ready to drop to the ground and one molting nymph were found on these three animals.

Since that time Mr. Mitchell has examined ten sheep in a large flock belonging to Col. J. C. Warden, whose ranch is in Victoria County, Tex. On two of these sheep specimens of *Boophilus annulatus* almost fully engorged were found. They were both located on the head, near the base of the ear. Colonel Warden states that late in the summer and fall the fever ticks cause considerable annoyance on his sheep. It is necessary to treat them continuously to prevent damage from screw-

worms, which are attracted by the wound left when the tick detaches itself or by the blood released when one happens to be crushed on the host.

It will be noted that fully engorged specimens of the fever tick have now been found on sheep by Mr. Mitchell in three different flocks in as many counties in southern Texas. It is expected that future observations will show a rather general occurrence on sheep.

There are several points of importance to be determined, as, for instance, whether the offspring of the ticks which have developed on sheep transmit splenic fever when placed on nonimmune cattle, and whether the sheep become diseased through the agency of the ticks. It is expected that the Bureau of Animal Industry will undertake investigations in the near future bearing on these points. The purpose of this circular is merely to call attention to matters of immediate practical importance.

It may possibly be important to note that there are some peculiar features of the cattle-tick problem in southern Texas this season. Various conditions have caused unusually large numbers of ticks to be present in the spring. According to the testimony of cattlemen the ticks have never been more abundant in the spring than they are this season. It is barely possible that this excessive abundance may have had something to do with the occurrence of ticks on sheep, and that under different conditions the sheep would not have become infested. Nevertheless, it must be remembered that in that portion of Texas as well as elsewhere the cattle ticks are frequently as numerous in the fall of the year as they have been this spring. In view of these facts it seems evident that it will be absolutely necessary in plans for eradication to exclude sheep from areas in which an attempt is being made to eradicate the ticks.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *June 19, 1907.*

United States Department of Agriculture.

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

MITES AND LICE ON POULTRY.

By NATHAN BANKS, *Assistant Entomologist.*

Everyone has seen hens squatting in a hole of dust, vigorously scratching, fluttering their wings and lifting their feathers in an effort to get the dust to the body. This is evidence that the hens are infested with mites or lice, and they are using the means most available to get rid of their tormentors.

Ordinarily the fowls, by this process, are able to keep the parasites in check, and although there is, of course, some loss in flesh and eggs there is no serious damage. But in the case of setting hens the mites and lice increase to an enormous extent, so that the young chick issuing from the egg is at the mercy of hordes of hungry parasites. Some claim that a single individual of these voracious parasites, attacking the throat of a young chick, may cause death. Various troubles are attributed by expert poultry growers to the presence of mites and lice, including bowel disease in summer, drowsiness, refusal to eat, gradual wasting away, loss of feathers, etc. Poultry are frequently supposed to be suffering from some disease when the real cause of their ill health is an excessive abundance of lice or mites.

MITES.

THE CHICKEN MITE.

The mite most commonly found on poultry throughout the United States, and the one called the "chicken mite," is scientifically known as *Dermanyssus gallinae* Redi. (See fig. 1.) It has long been known to naturalists, and occurs on fowls in Europe and other parts of the world.

DESCRIPTION AND HABITS.

It is an elliptical, somewhat flattened mite, nearly one-twentieth of an inch long, and plainly visible to the naked eye. Often it is of

a pale gray color, with darker spots; but after feeding it usually becomes more or less reddish, according to the amount of blood it has sucked from its host. It has eight rather slender, tapering legs, a pair of shorter feelers or palpi in front, and between the latter is a pair of needle-like mandibles with which it secures its food.

The adult mother mite lays her tiny eggs in cracks and crevices of the wood, usually where there is some manure or other filth. The mites when born are whitish in color, oval in shape, and have but six legs. They feed largely, if not wholly, upon filth, but when older attack the chickens. If a partly hatched egg is broken in the nest the mites swarm and feed upon it. After the young mites have fed for a few days they molt, or shed their skin, and appear with eight legs, looking more like their parents. Other molts occur before the

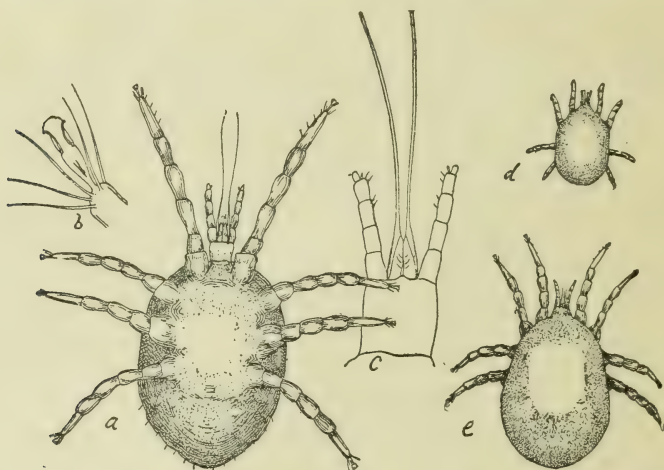


FIG. 1.—The chicken mite (*Dermanyssus gallinae*): a, Adult; b, tarsus; c, mouth parts; d and e, young. All much enlarged (from Osborn).

adult condition is reached, the mites becoming mature in about ten days from birth.

Darkness and dampness are favorable to the increase of the pests, and plenty of sunlight and good ventilation will do much to hinder them. The mites do not remain on the poultry all the time, but usually only long enough to feed; they then either wander about in search of another host or retire into crevices. They are most active at night, but when very numerous many can be found crawling about by day. By some means, possibly by the sense of smell, they are able to realize that a hen is near by, and within a few minutes after a hen has settled upon her nest the mites will be found upon her.

The chicken mite will attack other kinds of fowls, horses, and even man. The mite found upon pigeons, however, is now considered to

be a distinct species. Pigeons, therefore, do not spread the chicken mite, as was formerly supposed by many people.

The loss caused by the chicken mite is, of course, variable, according to the amount of infestation. Some writers consider this mite the most serious enemy of poultry, while others think it of secondary rank. In any case, it is a pest of such importance as to warrant the strictest measures of repression.

REMEDIES AND PREVENTIVES.

Cleanliness and sunlight are the best means of preventing an abundance of mites. A chicken house can not be kept too clean. It should be cleaned out every few weeks, at least, and it is a great advantage to have the nests and roosts so built that they can be removed and washed in some cleansing liquid.

A treatment much in favor is that of whitewashing the inside of the house. If this is done, about 4 ounces of crude carbolic acid should be added to each gallon of whitewash. Like all other treatments, this should be repeated in three or four days, to destroy the young which have hatched since the first application.

In cleaning the henhouse it is useful also to scatter a mixture of 3 parts of dry air-slaked lime and 1 part of sulphur. The doors and windows should be closed and the mixture thrown up to the roof till the air is filled with it. It will then settle upon everything, the sulphur killing many mites and the lime aiding in drying the droppings. Setting hens need not be disturbed.

But the best remedy against the "chicken mite" is to spray with kerosene emulsion. To make this, shave one-half pound of hard soap into 1 gallon of soft water and boil the mixture until the soap is dissolved. Then remove it to a safe distance from the fire and stir into it at once, while still hot, 2 gallons of kerosene or coal oil. The result is a thick, creamy emulsion. Dilute this stock mixture with 10 parts of soft water, and apply as a spray or with a brush, being careful to work it into all cracks, crevices, and joints of the building. Two or three applications on the same day are necessary to obtain the best results, and this treatment should be repeated in three or four days to kill the young mites which will have hatched since the first application.

OTHER MITES ON POULTRY.

Although the species mentioned, *Dermanyssus gallinae* Redi, is by far the most injurious, yet there are several other mites that attack poultry. The "itch mite" of fowls (*Cnemidocoptes mutans* Robin) is the cause of "scaly-leg." It does not, however, confine itself to the

legs, but often occurs on the comb and neck. The adults of this species are very small, whitish in color, and have very short legs. They burrow in the skin, causing an intense itching, and forming a crust of loosened tissue above their burrows. A good remedy is to bathe the infested parts in warm, soapy water, and then apply sulphur ointment. Naphthaline crystals powdered and mixed with 9 parts of lard also make an effective ointment.

Another closely related mite, *Onemidocptes gallinæ* Railliet, is sometimes found on hens. It burrows near the base of the feathers; and the itching induces the hen to pluck her feathers in a vain effort to stop the irritation. It is sometimes called the "depluming mite." Another similar mite, *Rivoltasia bifurcata* Rivolta, sometimes feeds on the feathers of fowls, but causes no injury.

In Texas, Arizona, New Mexico, and southern California there is a tick, *Argas miniatus* Koch (see fig. 2), which attacks hens, and in those sections is a more serious menace to poultry even than the "chicken mite." The adult tick is a flattened, elliptical, reddish, or mahogany-brown creature, about one-third of an inch long. The edges of the body are quite sharp, and from above one can scarcely see the small and slender legs. The surface of the body is finely and irregularly roughened or pitted. These ticks feed on the hens at night and retire to the crevices of the hen-house during the day. The eggs are laid in these crevices, and both ticks and eggs can be destroyed by spraying the inside of the house with kerosene. It is useful to rest the ends of the roosts upon something which the ticks can not cross, as a ball of tarred cotton, or the roosts may be hung by wires from above. The life history of this tick is not fully understood as yet, but there is no probability that it will spread to the North.

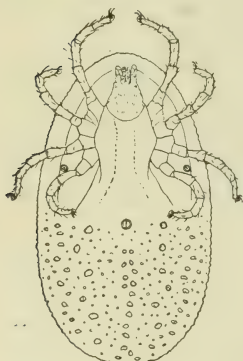


FIG. 2.—*Argas miniatus*, a tick which infests poultry. Greatly enlarged (original).

LICE.

The various species of lice affecting poultry are more numerous than the mites, but since they do not suck the blood they are less injurious.

THE COMMON HEN LOUSE.

DESCRIPTION AND HABITS.

The only species found in abundance throughout the country is known as *Menopon pallidum* Nitzsch (see fig. 3), the common "hen

louse." This is pale dull yellow in color, with more or less distinct darker marks on each side of the body, although often after feeding it is reddish or pinkish in color. The length is about one-twentieth of an inch, the legs are six in number, and the head is broad, rounded in front, with a small antenna or feeler on each side. It is always without wings.

This louse is very active, and seems to wander continually over the skin or among the feathers, apparently looking for something new, as any person will discover who handles a lousy hen. The eggs, or "nits," of this louse are tiny, elongate, oval objects, with the smaller end flattened and the larger end attached to the vanes and barbs of the feathers. If conditions are favorable, the young issue from the egg in about eight days, but they may be kept in a cool place for several months without loss of vitality. The young louse is much like the parent, having six legs and a broad head, but with a rather smaller body. It keeps close to the body of the host, molts several times, and in the course of two or three weeks, if not disturbed, will reach maturity. Lice are not provided with mandibles fitted to suck blood from a hen, but they use their short-toothed jaws to bite off the epidermal scales, or dandruff, and the edges of the feathers. The claws of the feet are sometimes very sharp, and continual pricking of the host draws blood, which is greedily eaten by the lice. This accounts for the reddish color of many specimens.

Dampness, filth, and warm weather favor the increase of these lice, and a setting hen in a foul nest is their paradise. At night they crawl about on the roosts, going from one fowl to another, so that one infested bird will soon cause the infestation of an entire flock.

The chickens do not suffer from loss of blood, but from the nervous exhaustion induced by the biting of their scales and the scratching and pricking from the claws, often resulting in sores or ulcerations. The continual worry and loss of sleep produce debility and bowel troubles. Little chickens are, of course, more susceptible and often die from the attacks.

Unlike mites, lice are usually confined to one kind of host, and the lice on ducks, geese, and pigeons are of kinds different from those on chickens.

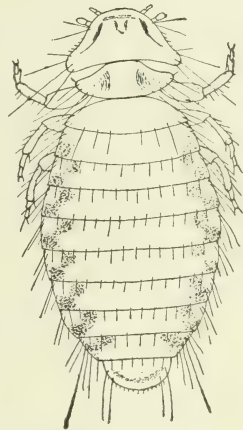


FIG. 3.—The common hen louse (*Menopon pallidum*). Greatly enlarged (original).

Many people who keep a few hens consider the infestation by lice a natural state of affairs, and so long as the lice are not so excessively numerous as to interfere seriously in egg production no attempts are made to exterminate them. Lice, however, are readily killed by a number of substances, although there is more or less difficulty in getting at them. Hidden among the feathers or close against the body the parasites are secure against any remedy unless it be applied very thoroughly. Moreover, one application is not enough. What will kill the lice may not affect the eggs or "nits," so it is necessary to repeat within a few days any method of treatment that may be used.

Carbolic acid, tobacco, sulphur, naphthaline, or any oily substance will kill the lice if it touches them.

Carbolic acid must be handled with great care, for it is a burning poison. It is used mixed with lime or kerosene. To make the lime mixture, stir 2 ounces of 90 per cent carbolic acid in 1 pint of cold water, sprinkle it in a half bushel of lime, and leave the lime to air slake. This can be sprinkled anywhere about the henhouse, but is most effective if put in the nests and mixed with the dust in the "wallow." If kerosene is used, take 2 ounces of carbolic acid to 1 gallon of kerosene, stir it thoroughly, and paint the mixture upon the roosts and nests, keeping the poultry out of the house until the mixture is dry.

Tobacco is used as an infusion, made by pouring hot water on tobacco stems. The hens are dipped into the liquid thus made. This is not a pleasant method to practice, and care should be taken to prevent the fowls from taking cold. Tobacco dust is the basis of various powders which are advertised to be used against lice. Their value depends largely upon the strength and freshness of the components. They are often used successfully, although frequently they are expensive.

Sulphur mixed with air-slaked lime, 10 pounds of sulphur to a half bushel of lime, is also often used against lice. This may be scattered everywhere in the house, or mixed in the dust wallow. Sulphur can also be used in fumigation. To avoid danger from fire, the sulphur or sulphur candle should be put on an old tin can or something similar, and this placed in the middle of a pan of wet ashes or earth. Light the candle and shut the house tightly for several hours; then air it well before allowing the hens to enter.

Kerosene may be used in conjunction with naphthaline. Dissolve in kerosene all the flake naphthaline it will take, and paint the roosts and nests with this saturated solution every week or so for a few months. Sawdust wet with this liquid may be placed in the

nest, but should be put beneath the straw, so that the eggs will not rest upon it. Naphthaline is not poisonous, however, and may be handled without danger.

OTHER LICE ON POULTRY.

Chickens are subject to the attacks of various other lice with habits similar to those of the species mentioned, but most of them are not common. One, *Menopon biseriatum* Piaget, is very like the common "hen louse," but larger, and with a more elongate body. Others belong to the genera *Lipeurus* (fig. 4), *Goniodes* (fig. 5), and *Goniocotes* (fig. 6). Several of these are known as "gray sucker lice." They do not move around as much as the *Menopons* and are often confined to one part of the body.

Sometimes they bury their heads in the scales of the skin or close to the base of a feather and remain a long time in one position. The species of *Lipeurus* are more slender than the common lice, and the *Goniodes* and *Goniocotes* are broader, with more prominent feelers or antennæ, and with darker spots on the borders of the body.

The remedies used against the common hen louse will at the same time

destroy any of these other lice that happen to be present.

A SURE PREVENTIVE FOR MITES AND LICE.

Since lice and mites have no wings and can crawl but short distances, it is evident that they are disseminated only from fowl to fowl. But if an infested hen or rooster is brought to the flock the parasites soon spread to all the birds. There is a possibility that lice may be carried by certain bird flies, but such flies have been found so rarely on poultry that this

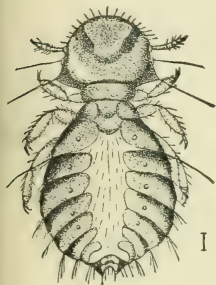


FIG. 5.—*Goniodes dissimilis*, a louse that infests poultry. Much enlarged (after Denny).



FIG. 4.—*Lipeurus variabilis*, a louse that infests poultry. Much enlarged (after Denny).

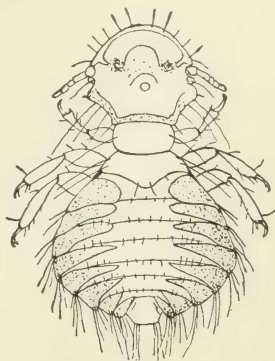


FIG. 6.—*Goniocotes abdominalis*, a louse that infests poultry. Much enlarged (original)

method of infestation need not be considered. It is therefore a sure preventive against mites and lice to keep only poultry hatched in an incubator and raised in a brooder. Build the hen house on a spot where none has been before; never buy fowls, raise them artificially; keep them away from other hens, and they will not be troubled by mites and lice.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *August 6, 1907.*

[Cir. 92]

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United States Department of Agriculture,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

THE SPRING GRAIN-APHIS OR SO-CALLED "GREEN BUG."*(Toxoptera graminum* Rond.)

By F. M. WEBSTER,

In Charge of Cereal and Forage-Plant Insect Investigations.

The early history in America of the spring grain-aphis (figs. 1-4), which has come to be generally known as the "green bug," was published in Circular No. 85 of this Bureau, and need not be reproduced

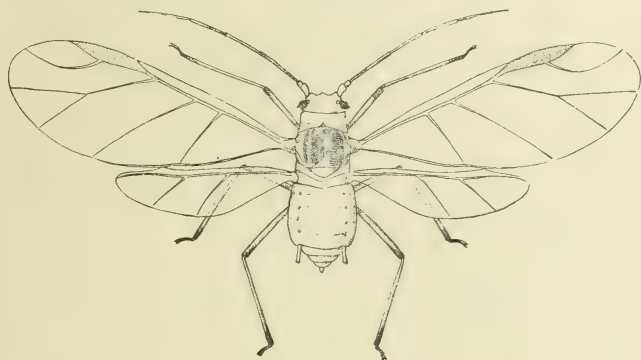


FIG. 1.—Spring grain-aphis (*Toxoptera graminum*): Male. Greatly enlarged. (Original.)

here. Suffice it to say that it is an imported species, long known to be destructive to growing grain in Europe, but not known in this country prior to 1882, and not as a destructive insect until 1890. The literature relating to this, the third and perhaps most destructive outbreak of the pest, is so misleading that this publication seems necessary in order to prevent misapprehension among farmers, and to afford them all possible helpful information in advance of future similar outbreaks.

DISTRIBUTION IN THE UNITED STATES.

The insect is usually common, and is found from New Mexico, Colorado, and Montana to the Atlantic coast, approximately covering the area south of latitude 41° , excepting New York, New Jersey, and New England, and east of longitude 105° . Within this territory its area of destructive abundance, as well as the severity of its attack during any year, will be regulated by two factors: First, the

presence of young growing wheat, oats, barley, or rye; and, second, weather conditions favoring its rapid increase and unfavorable for the development of its natural enemies. It will breed freely in the fields from an altitude of less than 20 feet above sea level on the At-

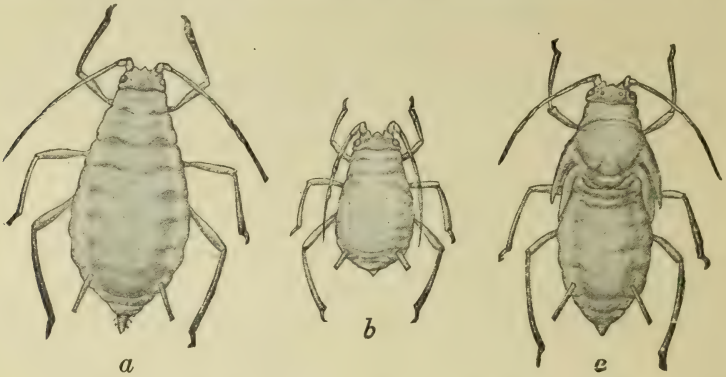


FIG. 2.—The spring grain-aphis or "green bug" (*Toxoptera graminum*): a, Wingless female; b, larva; c, pupa. Much enlarged. (From Pergande.)

lantic coast to an elevation of nearly 8,000 feet in New Mexico, and from eastern Washington, southern Montana, northwestern Minnesota, southern Wisconsin, northern Ohio, and southern Pennsylvania southward to extreme southern South Carolina, southern Texas, and

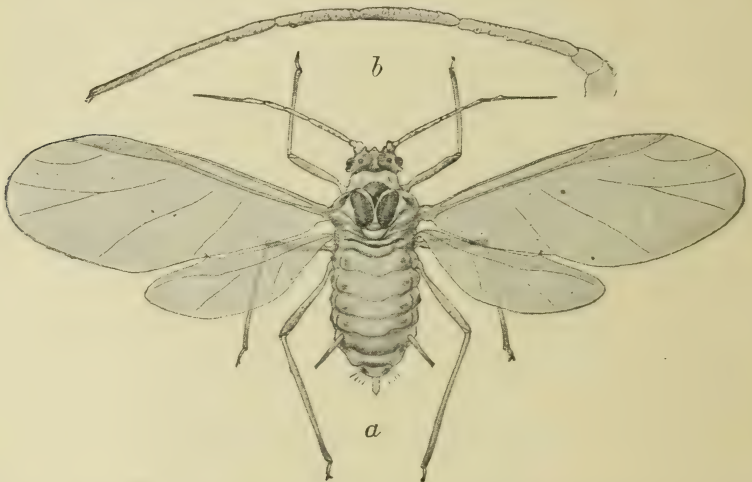


FIG. 3.—The spring grain-aphis or "green bug" (*Toxoptera graminum*): a, Winged migrant; b, antenna of same. a, Much enlarged; b, highly magnified. (From Pergande.)

New Mexico. Yet, with normal weather conditions during the first four or five months of the year, these facts signify absolutely nothing, for this insect will not be abundant enough to attract any attention by its injuries.

THE RELATION OF TEMPERATURE TO DESTRUCTIVE OUTBREAKS.

This insect, as with other closely allied species of aphides, reproduces in two ways. As cool weather approaches in autumn there occur in greater or less numbers both males and females, the latter depositing eggs (see fig. 4), and it is in the egg state only that, under normal weather conditions as to temperature, the "green bug" passes the winter, and from these eggs it originates in the spring. But from spring to fall there are neither eggs nor males; all are females, and these give birth to living young in a series of generations. With the normal cold of early winter these females gradually disappear and the winter eggs remain; but if the winter temperature is mild, and the temperature of the following spring abnormally cold, the summer method of reproduction continues throughout the winter and during spring. Indeed, it is not improbable that males and egg-laying females may be found in spring, especially in the South.

The "green bug" will breed freely in temperatures ranging from above 100° to below 46° F. As the young mature in eight days and themselves begin to give birth to young, it will be seen that an exceptionally mild winter followed by an abnormally cold spring offers the best possible conditions for the excessive increase of the pest, which would ordinarily begin breeding only in spring, and from the eggs.

With excessive reproduction and the destruction or aging of its food plants, this insect develops a corresponding abundance of winged migrating females, which are the means of the spread northward or outward from original centers.

The "green bug" in normal years—that is, when its breeding begins in spring—is effectively held in check by its natural enemies, and notably by a minute, black, wasplike insect, *Lysiphlebus tritici* Ashm. (see fig. 5) that deposits eggs singly in the "green bugs," the grubs hatching from the eggs feeding internally on the bug and destroying it (see fig. 6). Other natural enemies are the larvæ of certain predaceous flies, and the larvæ and adults of lady-beetles. The little wasplike parasite first mentioned, however, is the one that keeps the "green bug" in control in normal years, and in years when the latter is most abundant finally overcomes it, as was the case in 1907 in Kansas, North Carolina, and other States in the more northern part of the range of the pest.

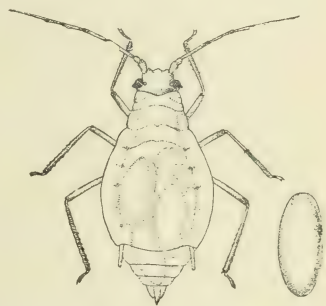


FIG. 4.—Spring grain-aphis (*Toxoptera graminum*): Egg-laying female with eggs in body, greatly enlarged; at right, egg, still more enlarged. (Original.)

Unfortunately this parasitic wasp—as with the other beneficial insects—is active only while the temperature is above 56° F., or at least 10° above that at which the “green bug” breeds freely; and

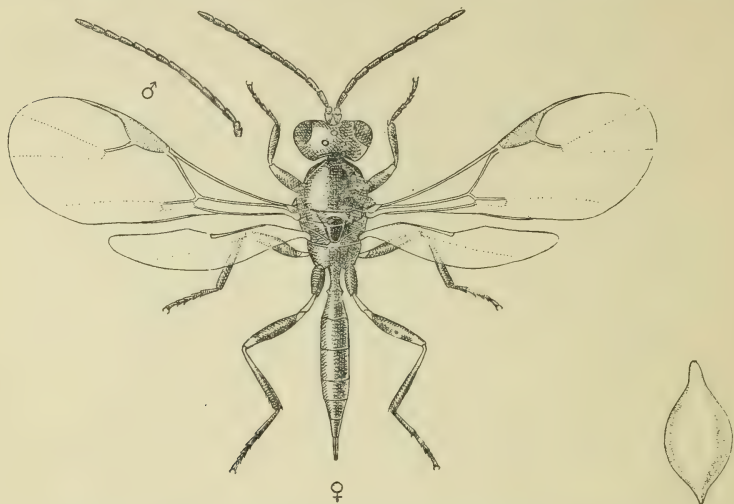


FIG. 5.—*Lysiphlebus tritici*, principal parasite of the spring grain-aphis: Adult female and antenna of male, greatly enlarged. Egg of *Lysiphlebus tritici* at right, highly magnified. (Original.)

herein is the whole secret of the irregular disastrous outbreaks of the “green bug” in grain fields. As accounting for the outbreak in the year 1907, the “green bug” had had a whole winter and the following late spring in which to breed and multiply unmolested, and it accomplished its principal damage, as in Texas and southern Oklahoma, before the weather was warm enough for the parasite to increase sufficiently to overcome it.

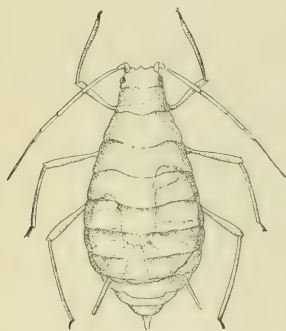


FIG. 6.—Wingless female of “green bug,” containing larva of the parasite *Lysiphlebus tritici*. Much enlarged. (Original.)

As further illustrative of the important bearing of weather conditions, it is found that in the case of the three important outbreaks of this insect, namely, for the years 1890, 1901, and 1907, the temperature for the first five months of each of these years, including the latter part of winter and spring, was above the normal for the winter months and below the normal for the

spring months; in other words, warm winters and cold, late springs.

The little parasitic wasp which is so useful in the control of this pest is native to this country, widely distributed, and every year does its work with the “green bug” and with other aphides. It is always

present in grain fields, as shown by its appearance every year, to war on these pests whenever the weather conditions make its breeding and multiplication possible, and its rate of breeding is so rapid (there being a generation about every ten days) that with a week or two of favorable weather it gains control over its host insects and destroys them.

FOOD PLANTS.

The spring grain-aphis is essentially a leaf-infesting insect, rarely being found on the stem. While preferring oats, it will readily attack wheat, rye, and barley, and may often be found on the underside of the lower leaves of corn. Corn excepted, its effect on the leaves of grain, when present in large numbers, is to cause the infested leaves to change to a red color, which seems to be very characteristic of Toxoptera and does not follow attacks of other species of aphides on these grains. The insect has also been found breeding upon a considerable number of grasses, any one of which may constitute its alternating food plant upon which it may survive the summer in different portions of the United States. It has been found breeding freely upon marsh foxtail (*Alopecurus geniculatus*) in Oklahoma by Mr. W. J. Phillips, and by Mr. C. N. Ainslie in Kansas; on *Agropyron occidentalis*, also in Oklahoma, by Mr. Phillips, and by Mr. E. O. G. Kelly and Prof. C. P. Gillette in Colorado. Slender wheat-grass (*Agropyron tenerum*) was found moderately infested by Mr. Ainslie at Las Vegas, N. Mex. The species was found breeding upon *Bromus* at Washington, D. C., and also upon Porter's chess (*Bromus porteri*) at Las Vegas, N. Mex., and on an undetermined species of *Bromus* at Mesilla Park, N. Mex., all by Mr. Ainslie. The writer observed it very abundantly on orchard grass (*Dactylis glomerata*) in Indiana in 1890, and again excessively abundant in a small isolated meadow of this grass near Midlothian, Va., in April, 1907. This meadow was located in a region not adapted to the growing of grain, and there was no field of growing wheat or oats within 5 miles. Mr. Kelly found it in Montana, inhabiting marsh spike-grass (*Distichlis spicata*) in such abundance as to be damaging this grass, which in that part of the country is known commonly as "salt grass." It was found inhabiting slender wild rye (*Elymus striatus*) at Las Vegas, N. Mex., by Mr. Ainslie. Mr. Phillips found it attacking little barley (*Hordeum pusillum*) at Beloit, Kans., and Kingfisher, Okla., while the writer found this to be of frequent occurrence throughout Kansas. Mr. Kelly observed it abundant on squirrel-tail grass (*Hordeum jubatum*) in Montana, while Mr. Ainslie found it moderately abundant on *Hordeum caspitosum* near Cimarron, N. Mex. Wherever Kentucky blue-grass (*Poa pratensis*) grows, the insect will probably be found breeding upon it through-

out the entire summer. In fact, this has been actually observed to occur in the city of Washington. Mr. Phillips has observed the same thing in Indiana, and throughout the northern sections of the country where the Toxoptera occurs it is more likely to be found on this plant during summer than upon grain, excepting, perhaps, during seasons of excessive abundance. Mr. Ainslie also found it moderately abundant on beard-grass (*Polypogon monspeliensis*) about Albuquerque, N. Mex. It has been found breeding on yellow foxtail or pigeon-grass (*Ixophorus glaucus*) by Mr. Phillips at Richmond, Ind., and on green stipa (*Stipa viridula*) at Las Vegas, N. Mex., by Mr. Ainslie. In the latter case the grass was heavily infested. As one or more of these grasses will be found to occur in almost every portion of the United States, it would appear that the nonoccurrence of Toxoptera in any considerable section of country can not be due to a lack of uncultivated food plants. Of food plants other than grasses we have only the one observation made by Mr. Phillips at Kingfisher, Okla., April 23, 1907, where a species of ragweed growing up in a badly damaged wheat field was quite heavily infested with Toxoptera, at the time breeding freely on this plant.

The outbreak on the grounds of the Department of Agriculture was notable in some respects, in that the continued close cutting of the blue grass supplied a continual fresh, tender growth as food for the "green bug," thus preventing the development and escape of winged females; and especially is it notable in view of the total lack of *Lysiphlebus tritici*, the most important of the natural enemies of this aphid. The only natural enemy found in this case feeding upon the "green bug" was the diminutive black and yellow lady-beetle (*Hyperaspis undulata* Say), not previously known in connection with this pest.

When this outbreak became known to Mr. E. M. Byrnes, superintendent of Experimental Gardens and Grounds, he at once had the entire infested block sprayed with a solution of one-half gill of rose-leaf nicotine to each gallon of weak soapsuds. The application was, however, ineffective. Four days later a strip through this plat was thoroughly saturated with a strong solution of barnyard manure, made by soaking the manure in water. While there was no evidence that this killed any of the "green bugs," after nine days the pest was notably less on this area than where the application of manure solution was not made.

A series of experiments was then undertaken under the writer's direction by Mr. E. O. G. Kelly, as follows:

Tobacco dust was applied at rates of one-fourth, one-half, and 1 pound to each 100 square feet, but after over a week had elapsed

from the date of application no effect was to be observed and no dead insects were found.

Kerosene emulsion was applied at 8 and 10 per cent strengths. There was practically no difference in the effect of these two strengths, and at the end of nine days no "green bugs" were to be found on the areas so treated. Also there was no perceivable injury to the grass.

Whale-oil soap solutions, varying in strength from one-fourth of a pound to 2 pounds of soap to each 5 gallons of water, were applied to similar areas. In this case the stronger solution injured the grass slightly, but not permanently; in the case of the lesser strengths there was no injury whatever. The effect on the "green bug" was the same in every case. They were not only literally exterminated over the areas treated, but the applications seemed to protect from a reinestation. In case of even the weakest solution an examination, five days after the application was made, revealed the "green bugs" in myriads and breeding freely on the untreated space, while but 8 inches away and on the treated area living bugs were scarcely to be found, though the dead were to be observed almost as abundantly as were the living on the space untreated. It must be remembered, however, that these experiments were carried out in grass kept closely cropped by frequent use of the lawn mower, and the results obtained in no way reflect upon similar experiments carried out by Messrs. Ainslie and Phillips in the grain fields of Oklahoma.

INVASION OF 1907.

A better appreciation of the interrelation of the "green bug" and its principal parasitic enemy can be conveyed by giving a chronological statement of our investigations of the very disastrous invasion of the "green bug" during the winter and spring of 1907.

The first rumors of injuries by this pest came to us early in January from east-central Texas, where the "green bugs" were reported to Mr. W. D. Hunter, in charge of cotton boll weevil investigations of this Bureau, as attacking fall oats. During this month in Texas, east of a line drawn from near Gainesville through Abilene and San Antonio to Galveston, the temperature was 9° above the normal. Within this area was a smaller one, the boundaries of which may be indicated by a line drawn from Texarkana to Fort Worth, Waco, and Joaquin. Over this latter area the temperature for the same month was 12° above the normal, and within this area the pest began its work of destruction.

Also, judging from data received later, the pest began to breed rapidly in fall-sown oats in southern South Carolina, where the temperature was from 6° to 9° above the normal.

During February all over the region west of the Mississippi River and the Great Lakes the temperature was above the normal, and in the Carolinas it was only slightly below. During this month much damage seems to have been done in Texas, and there is every probability that the pest was breeding freely in the Carolinas, though it had not yet been reported from the latter States.

Up to this time the outbreak in Texas was being investigated by Mr. E. C. Sanborn, an agent of this Bureau detailed to the Texas Agricultural Experiment Station. The first report of the insect outside of Texas was under date of March 6, from Mr. C. H. Drake, of Summers, Ark., who reported that "a small green bug" had destroyed the wheat in spots in the fields in his locality. This letter, received March 11, led to the prompt dispatching of Mr. C. N. Ainslie for the West, with full instructions to investigate the outbreak thoroughly, to experiment with measures for destroying the insects in the fields, especially over the spots where they seemed to be most abundant, and to determine what could be accomplished in checking the ravages of the pest by the early introduction of natural enemies into the infested fields. Arrangements were perfected with Mr. W. D. Hunter to ship to Arkansas living parasites (*Lysiphlebus tritici*), which were then abundant in Texas, and the same train by which Mr. Ainslie reached Summers brought several boxes of the parasites. These parasites were promptly placed in the infested fields and liberated March 18. But Mr. Ainslie found that both the lady-beetles and the little wasplike parasites (*Lysiphlebus tritici*) were already present at Summers and near-by points in greater numbers than could possibly have been introduced. The latter were simply everywhere, running about over the young grain plants and placing their eggs in the bodies of the "green bugs."

Clearly the importation of parasites would be useless under these conditions, and Mr. Ainslie, hoping to find a more favorable field for the introduction of parasites or direct experimental work with remedies, proceeded, on March 23, for various points in Oklahoma.

At Chandler and Guthrie, March 23 to 25, the pest was very abundant, but the conditions at these points were again even less favorable than in Arkansas for the introduction of parasites. For example, on one blade containing about 150 of the "green bugs" Mr. Ainslie counted 25 that were parasitized. He then proceeded to Kingfisher (March 26) and here found the parasites apparently less plentiful than at the other points visited, which were to the eastward.

Arrangements had been made with Mr. Hunter to furnish parasites from Texas fields when these were called for, and in response to a telegraphic request he dispatched a quantity of material collected by his assistants in Texas and in southern Oklahoma. When this was

received and the parasites liberated in the infested fields, native parasites were already issuing in great numbers. In other words, the parasite was already beginning unaided its active work of control. By March 27 the "green bugs" developed winged adults in great numbers, and these seemed to drift northward.

Mr. Ainslie was instructed to look for a region to the northward where the "green bug" was just starting, and he made his first stop, March 30, at Wellington, Sumner County, Kans., and found the conditions there such as to offer a favorable field for experimentation with parasites.

By April 1 the fields about Wellington were generally, though sparsely, infested with the "green bug," represented in many cases by winged females that had seemingly migrated to these fields and were giving birth to their young. Lady-beetles were common, but none of the *Lysiphlebus* was observed. After a couple of days spent in the vicinity of Wellington, Mr. Ainslie returned to Kingfisher to secure parasites for introduction into southern Kansas, but in the meantime severe weather, accompanied by heavy frosts, had prevailed, and the parasites formerly abundant at Kingfisher had become exceedingly scarce. By the 5th, however, he began again to find very many parasitized "green bugs," and by the 7th the parasites themselves began to appear again. A bushel of wheat plants, now nearly covered with parasitized "green bugs," was collected at Kingfisher and taken to Wellington April 9. At this time fully 12 per cent of the "green bugs" at Wellington were already parasitized, while on the 12th Mr. Ainslie counted as many as 11 parasitized individuals on a single blade of wheat.

About the middle of March an appeal came to this Bureau from the Texas Grain Dealers' Association, through their secretary, Mr. H. B. Dorsey, at Fort Worth, to investigate the "green bug." In response to this appeal Mr. W. J. Phillips, of the Bureau staff, was dispatched to Fort Worth, arriving on the 27th. Several days spent in examining fields in the vicinity of Fort Worth demonstrated that the "green bug" had totally destroyed the grain in that vicinity and disappeared, and there was no opportunity for experimental work. He then went, by instruction, to Hobart, Okla., and later relieved Mr. Ainslie at Kingfisher, and, in response to a telegram from Mr. Ainslie, sent an amount of parasitized wheat from Kingfisher to Wellington equal to or larger than the first shipment.

All of the material which Mr. Ainslie took with him from Oklahoma and that supplied him by Mr. Phillips was placed in a single wheat field near Wellington. It is safely estimated, from counts of average wheat blades, that upward of two and one-half millions of parasites were thus liberated in a single wheat field on April 9, and

by this time many were already there. This introduction of parasites was carried out in order to give a decisive test as to whether it was possible to aid in protecting fields in this manner along the advance line of invasion. The weather was still cold, and if the artificial introduction of parasites would, with the return of warmer weather, hasten the control of the "green bug," the introduction of such large numbers would clearly demonstrate this fact. And if such introduction on a large scale proved favorable, it would show reasonable ground for the more general introduction of parasites in lesser numbers.

There was a minor introduction of *Lysiphlebus* started at McPherson, Kans., April 18, though this parasite was already found in the fields in that vicinity at that time.

The weather during the whole of April was generally cold with, as on May 4, an occasional storm that is known to have killed many of the parasites, and though there were brief periods of warm weather during which the parasites would increase rapidly, the *Lysiphlebus* did not finally overcome the "green bug" in southern Kansas until about the middle of May.

As will be observed, this experiment was made under weather conditions almost uniformly unfavorable to the parasite and favorable to the development of the "green bug." There is no reason for supposing that the weather would affect the introduced parasites differently from those already present when the introduction was made.

Mr. Ainslie remained in the vicinity of Wellington, and more briefly at McPherson and Sterling, for the purpose of watching these experiments, and he was, moreover, in direct communication with Mr. Phillips in northern Oklahoma; and the two were therefore able to keep under their observation a wide range of country, thus eliminating the possibility of oversight or misconception on the part of either that might otherwise have occurred.

It was during this period of generally cold weather in late April and early May, interspersed by shorter periods of weather favorable to the parasites, that the latter increased generally throughout Kansas and, judging from reports, also in Missouri and Colorado. It wanted only the more extended warm spell that came soon after to enable them to get the upper hand and subdue the pest, as they did throughout the southern Atlantic coast section earlier in the season.

The field in which the two and a half million *Lysiphlebus* were introduced and liberated on April 9 did not, at the time of the overcoming of the pest in this and the adjacent country in May, indicate any benefit whatever above other fields, near or remote, where no

artificial introductions had been made. The result of the minor experiment at McPherson was, as reported by Mr. Knaus, no more favorable.

During the last two weeks of April a great many small lots of parasites were distributed over the southern and central counties of Kansas by Mr. S. J. Hunter, of the Kansas State University. The artificial sending out of these parasites by Mr. Hunter and the test of distributing an enormous quantity in a single field, described above, were legitimate experiments, but the evidence showed very conclusively that they resulted in no benefit whatever. In other words, as noted above, the parasites were already infesting 12 per cent of the "green bugs" at Wellington, Kans., April 9, when the artificial introduction was made, and 50 to 75 per cent at Kingfisher, Okla., at the same date, and they were only waiting for weather conditions to make it possible for them to do their work. Just as soon as the favorable weather arrived the parasites bred enormously and quickly overcame the "green bug." In no case was there a field of the hundreds examined in southern Kansas where the parasites natively present did not outnumber by many thousands or hundreds of thousands any number that could have been introduced artificially, at a time when weather conditions had become such that the liberations could have had any benefit. As shown by the careful investigations of the agents of this Bureau in the field, and independently of Prof. E. A. Popenoe, entomologist of the Kansas State Agricultural College, and his assistants, the parasites were equally abundant in all fields in May, when weather conditions became favorable, irrespective of whether distributions had been made or not.

The weather, therefore, is the important influence. As demonstrated by the experience of this and other years, these parasites, always present in limited numbers, will overcome the aphids unaided as soon as weather conditions permit, and no artificial introduction, great or small, appears to hasten or increase their efficiency.

The writer left Washington for Kansas May 13 to take personal charge of the field work in relation to the "green bug" and to make a thorough survey of actual field conditions. The "green bug" at this time (May 15) had become abundant in oats as far north as Manhattan, Kans.; but wherever present there were numbers of parasites also already in evidence. Indeed, Mr. Phillips found this to be true at Kearney, Nebr., which point he visited about a week later. In no instance was a field observed, either in the vicinity of Manhattan or, during the next week or ten days, anywhere in Kansas, where the parasite was not present wherever the "green bug" occurred.

A further experiment, this time tried for the purpose of testing the possibility of hastening the work of the parasite during favorable weather by large introductions, was carried out as follows: The subjects of the experiment were two fields of oats, each containing 4 acres. In one of these it was determined to introduce enormous numbers of parasites artificially, keeping records of this field for comparison with the other field in which no introductions were made,



FIG. 7.—Stalk of wheat, the leaves covered with dead “green bugs” killed by the parasite *Lysiphlebus tritici*. About natural size. (Original.)

thus determining the measure of benefit, if any, which resulted from the artificial introduction. Mr. Ainslie was instructed by wire to ship from Wellington, Kans., 6 bushels of the wheat plants that had been destroyed by the “green bug” and which, in some cases, were literally covered with the parasitized bodies of the pest, upward of 500 having been found on a single plant. (See fig. 7.) Before taking up the ex-

periment, however, it was desirable to know just what the conditions were under which it was begun. As stated above, one of these oat fields was used for the experiment of introducing parasites, while the other was kept as a check. The fields were so widely separated that the introductions could not have spread from one field to the other. Six areas of a square yard each, selected for the examinations in different parts of each field, were gone over by Mr. Phillips and two of Professor Popenoe's assistants. Examinations of both of these fields, made on May 17 and 18, showed that the field in which the parasites sent from Wellington by Mr. Ainslie were to be liberated contained approximately fifty millions of the unparasitized "green bugs" and approximately one and three-quarter millions that were undoubtedly parasitized; in other words, approximately 3.5 per cent of the "green bugs" were at that time parasitized. In the check field the parasites were even more abundant, about 7.8 per cent being there found, by similar counts, to be parasitized.

On May 18 parasites from 12 packages, each containing about half a bushel of wheat plants, were liberated in one of these fields. Now, a count similar to that made before the parasites were introduced was made on May 23, and this showed that the percentage of parasitism in the field in which the experiment was carried out had increased only to 5.4 per cent, while in the field in which no parasites had been liberated it was 19.3 per cent. On May 27 a similar count was made, when the percentage of parasitism in the field where the introduction was made was 27.1 per cent, while in the check field it was 32.5 per cent. Clearly, under weather conditions favorable for their development, an introduction of these parasites to the extent of millions, carried out under field conditions, did not indicate enough efficiency to afford any encouragement for the use of this measure in the protection of the grain fields of the farmer in case of future attack.

With all the artificial introductions of this parasite that were made in the grain fields of Kansas and adjacent States and Territories, there is no probability that a single bushel of grain was saved thereby or that the United States harvested one bushel more of grain than it would have harvested had no introductions of parasites been made or attempted. In substantiation of this statement it is interesting to note the history of the "green bug" during 1907 throughout North and South Carolina, upward of a thousand miles from where any introduction of parasites had been attempted, excepting two that the writer himself conducted. A considerable amount of material was sent from Winston Salem, N. C., on April 20, to a point a few miles west of Richmond, Va., where it was introduced into a small meadow of orchard grass, with no grain field within 5 miles.

But even here the effect was uncertain, as the writer had found the parasite present in this locality before the introduction was made. In the other case a larger consignment was sent from the same locality in North Carolina to Sumter, S. C., to be placed in a field of oats that the writer visited in company with the owner on the 16th of April, when parasites were found in considerable numbers. In this case the owner of the field, writing under date of June 18 and reporting on the outcome of the experiment, said:

I am sorry that the information to be derived from our experiments with the parasites is so indefinite. It just happened that other conditions probably overcame the aphids before the parasites had time to multiply sufficiently to get in their work. About the time that your box was received weather conditions changed somewhat from cool to warmer weather and the bugs seemed to disappear very rapidly. From the day the bugs disappeared, the oats, the only grain grown, began to improve, and while they will not make a full crop by any means, they are much better than we anticipated when you were here.

This is, as the writer personally observed, also the history of the disappearance of the pest in western North Carolina, where both fall wheat and fall oats are grown and where no parasites were introduced, but where they were literally swarming on April 20.

From all of this it would seem that throughout the greater areas over which this insect becomes injurious it has so far been impossible to assist the work in any way. We have apparently been wholly unable to aid the parasites in getting the upper hand. They accomplished their work earlier in the Carolinas than in the West, but reference to the records of the Weather Bureau will show that the weather conditions as regards temperature were precisely such as to bring this about.

The only possibility of accomplishing anything by the artificial use of natural enemies of the "green bug" seems to be in Texas and South Carolina, where the pest gets its start earliest, making its appearance in the fields in spots of greater or less area in the fall or early winter. If these incipient outbreaks can be stamped out by farm methods, as indicated further on, or by the encouragement of parasites, or if they can be so weakened as to prevent the "green bug" from developing in such enormous numbers, it will serve to protect the grain crops not only of these two States, but of all those to the northward over which the pest ravages in seasons favorable for its development. The Texas Agricultural Experiment Station is contemplating an experiment whereby they hope, by the artificial introduction at the proper time of a large number of the natural enemies of the "green bug" into these spots of early infestation, to forestall a future outbreak. If this can be accomplished it will prove of great benefit to the farmers. Whatever the outcome may be, the experiment seems worth trying.

DEVELOPMENT AND INFLUENCE OF *LYSIPHLEBUS TRITICI*.

Although there are several natural enemies of the "green bug," including one recently described by Dr. L. O. Howard as *Aphelinus nigritus*, yet all of them seem to be of little importance as compared with the one minute parasitic species, *Lysiphlebus tritici*. It is this species, or what we are at present terming as such, that normally holds Toxoptera in check in this country, and so long as its development and activity are not obstructed by adverse meteorological conditions it will probably continue to control it. Indeed, so important is this insect and so powerful is its influence that in a short space of from ten days to two weeks it can overcome a most serious outbreak of Toxoptera, and thus save from destruction vast areas of growing grain. The species winters over in the field in the body of its host. In many cases these parasites, having been prevented from emerging the previous fall by the advent of cold weather, hibernate as nearly developed or fully developed adults, ready to emerge when the temperature rises to about 56° F. and remains there for a sufficient length of time. This is clearly shown by the fact that Mr. E. O. G. Kelly found hibernating adults at Leavenworth, Kans., on November 13. In one lot of 50 dead, parasitized Toxoptera that had been washed or rubbed from the leaves of the young grain and taken from the mud about the wheat plants on February 28, after the winter was practically over, Mr. Kelly found 17 containing full-grown larvæ of the parasite, 12 containing pupæ of a light color, and 21 containing dark-colored pupæ, the latter evidently ready to develop promptly with the advent of warm weather. Mr. Kelly, on the same date, also secured a large number of Toxoptera in various stages of development that were hibernating in wheat fields near Leavenworth, Kans. The weather had been such as to preclude the possibility that these had been recently parasitized. Yet some of them soon began to show the yellowish color characteristic of Toxoptera parasitized by *Lysiphlebus*, and adults were afterwards reared from them. This shows conclusively that the *Lysiphlebus* parasites hibernate in advanced stages of development in the bodies of their host, which they have killed the previous autumn, and also as larvæ in those passing the winter from half to fully grown.

The female *Lysiphlebus* is even more prolific than the female Toxoptera. Mr. Phillips has found females which had upward of 400 eggs in their ovaries, and Mr. Kelly has reared in some cases 206 individuals from a single mother *Lysiphlebus*. The eggs are lemon-shaped and white. When excessively abundant this parasite will thrust its ovipositor into old and young aphides of both sexes, including the sexual female even though previously parasitized; and Mr. Phillips has observed that it will even oviposit in the dead bodies

of those that have been killed by fungous attack. When its numbers are not so great it shows more discrimination and seems to prefer half-grown individuals for oviposition.

This species of *Lysiphlebus* is parthenogenetic, as was first observed by Mr. Phillips at Richmond, Ind., and afterwards more fully elucidated by Messrs. E. O. G. Kelly and T. D. Urbahns at Wellington, Kans. The experimental breedings by Mr. Phillips in 1907 indicated that the offspring of virgin female *Lysiphlebus* were nearly always exclusively males. In a series of upward of 80 breeding experiments carried on indoors, in 1908, by Kelly and Urbahns, only 48 gave results of any kind. In only four of these were females produced, the others giving exclusively males. In the 4 exceptional cases the females remained virgin, and all finally gave birth to males alone, 2 with the first generation, 1 with the second, and 1 with the third. The mode of procedure was as follows:

Starting with a mated female, the females from among her offspring were isolated, even before emergence. On their appearance these were given *Toxoptera* reared under cover to preclude parasitism; the few females from among the second generation were again isolated in the same manner, the females in all cases being kept unmated. It was thus found possible to breed a limited number of females parthenogenetically to and including the third generation. Beyond this all offspring were males, this seemingly being the limit. Just why such a large percentage of these experiments should have proved abortive is not clear. The conditions under which they were carried out were of course unnatural but much more protected from the adverse elements of the open field.

The egg of the *Lysiphlebus* normally develops to the emerging adult in about ten days, during the first six of which the host insect remains alive, and at the end of which it commences to take on a yellowish hue, the larva of the parasite showing clearly through the skin of the abdomen.

The celerity with which an invasion of *Toxoptera* is overcome by *Lysiphlebus* is frequently a matter of wonder, as it hardly seems possible that this host alone could be the source of the swarms of parasites that make their appearance after a few warm days have elapsed in the midst of an unseasonably cool spring preceded by a winter abnormally mild.

In order to determine the origin of these myriads of parasites Messrs. Kelly and Urbahns began a long series of experiments at Wellington, Kans., to determine whether there might not be a multiplicity of host species from which great numbers of *Lysiphlebus* would emanate to fall upon and destroy *Toxoptera* whenever it becomes excessively abundant. The entire failure to introduce these

parasites in advance of an invasion of this character from the South, as was the case in Kansas in May, 1907, has indicated that such introductions were not possible and that to attempt it was veritably "carrying coals to Newcastle."

Female individuals of *Lysiphlebus* from the cabbage aphid (*Aphis brassicae* L.) taken in the field were first allowed to parasitize *Toxoptera* and from the latter the adults were obtained. This experiment was several times repeated. Females of *Lysiphlebus* reared under cover from the corn root-aphid (*Aphis maidi-radici* Forbes) were in two cases allowed to parasitize *Toxoptera* and adults obtained. Females of *Lysiphlebus* were taken from *Aphis setariae* in the field and the issuing parasites in two cases allowed to parasitize *Toxoptera* and adults secured. This experiment also was repeated several times. Female individuals of *Lysiphlebus* were taken from the corn leaf-aphid (*Aphis maidis* Fitch) in the field and the adult parasites permitted to parasitize *Toxoptera*, from which finally the adults emerged. This experiment was repeated several times. Female specimens of *Lysiphlebus* were taken from the cotton or melon aphid (*Aphis gossypii* Glov.) from New Mexico and given *Toxoptera* as a host, the adult parasites developing successfully therefrom. Female specimens of *Lysiphlebus* were taken from *Aphis setariae* in the field and given *Toxoptera* as a host, their offspring transferred to *A. maidi-radici*, and the next generation transferred back to *Toxoptera*. Female individuals of *Lysiphlebus* were taken from *A. setariae* in the field and allowed to parasitize *Toxoptera*, their offspring transferred to *A. setariae*, the next generation to *Toxoptera*, and the following generation to *A. brassicae*, from which adults were secured.

In many cases these breedings were reversed. The only cases of failure were in attempting to transfer *Lysiphlebus* issuing from *Toxoptera* to *Chaitophorus* and in transferring *Lysiphlebus* issuing from *Toxoptera* to *Macrosiphum rubbekiae*. These experiments were reversed with the same results.

The female goes about, if in grain fields, among the plants, and when she finds an aphid she quickly throws her abdomen underneath her body and between her legs and with a springlike motion thrusts her ovipositor into the body of the aphid (fig. 8), leaving therein a



FIG. 8.—*Lysiphlebus* depositing its eggs in the body of a grain-aphid. Much enlarged. (Original.)

tiny egg. This egg hatches into a larva in a few days, and the usual position in the body of the "green bug" of the larva up to the time it becomes full-grown is shown in fig. 6, page 4. Up to this time it has fed within the body of the "green bug" without reaching any of the vital parts, but preventing to a greater or less degree the giving of birth to young. This is an important fact, for, as the parasite seems to prefer partly grown young, it begins to check the increase of the pest before the death of the "green bug" takes place. Mr. Phillips has found that females parasitized at this period of their development do not reproduce for more than a very few days. After about six days the larva of the parasite reaches full growth and becomes more active, working its way about within the still living body of its

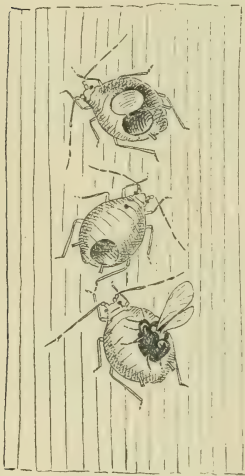


FIG. 9.—Dead "green bugs," showing hole from which the matured parasite of *Lysiphlebus tritici* emerges. The top figure shows the lid still attached, but pushed back; the bottom figure shows the parasite emerging. Enlarged. (Original.)

host, which now dies a seemingly terrible death. The motions of the parasitic larva within cause the skin of the "green bug" to become rotund in shape, as shown in fig. 9; the skin also becomes darker and hardens. Within four days (the life cycle in warm weather occupying about ten days) the adult *Lysiphlebus* emerges through a round hole in the dried skin of the "green bug," as shown also in fig. 9. In fields that have been destroyed the leaves become almost covered by their brown bodies, as shown in fig. 7. As stated, many of the "green bugs" are stung by the *Lysiphlebus* while quite young, and if these develop to winged adults, as they do at times in myriads and drift away to distant fields, they carry the parasite with them in their bodies. One of these parasitized winged females is shown in fig. 10.

The very act of migration of the "green bug," therefore, brings the parasite, and there is no need of artificial introduction, for

if the center from which the "green bug" is migrating has the parasites, as it always does, the latter are of necessity carried by their hosts, and, furthermore, the adult parasites fly with the latter with favoring winds.

During strong winds the *Lysiphlebus* does not use its wings, but crawls about over the plants and probably does not become scattered by gales. But in warm, comparatively still weather the writer has observed both winged "green bugs" and parasites crawling about on the windows of railway coaches many miles away from seriously infested fields of grain.

EXPERIMENTS IN DESTROYING "GREEN BUGS" OVER SMALL AREAS.

On leaving Washington both Mr. Ainslie and Mr. Phillips were instructed to place themselves in the position of a farmer whose grain fields were beginning to show the presence of the "green bug" by small deadening spots, and to leave nothing undone or untried that would seem to afford relief and save the crop.

Mr. Ainslie instituted some experiments in the use of a brush drag at Summers, Ark., and Mr. Phillips carried out similar experiments at Hobart, Okla., but in neither case was the measure sufficiently effective to warrant its recommendation. Experiments in rolling infested fields with heavy farm rollers were conducted by both of these agents, but it was invariably found that this measure was only effective on smooth lands. When the seeding is done with a grain drill, as most of it is, the plants grow up in the bottoms of slight furrows, and the roller comes in contact with the ridges only, leaving the young plants and their inhabitants almost wholly untouched. This measure, also, is therefore of little practical value.

Mr. Ainslie tried dusting with lime and also with sulphur, but both substances were ineffective.

Both Mr. Ainslie and Mr. Phillips carried out a series of careful experiments in spraying with kerosene emulsion and with

whale-oil soapsuds. From these experiments it was found possible to destroy 50 per cent or more of the "green bugs" at an expense of about \$4 per acre. This treatment, of course, is intended for use only where, as seems to be more usual to the southward, the outbreaks of the pest originate in spots in the fields.

Mr. Ainslie also tried covering some of these spots with straw and burning it, thus destroying, of course, both grain and "green bugs." This, too, gave encouraging results, and probably would prove effective if applied earlier in the season, when the pest first begins to appear and the infested spots are small.

At Hooker, Okla., Mr. Phillips tried the efficiency of plowing these spots under, and as the field in which he was working was isolated and the "green bugs" did not make their way in from without, he was able to show conclusively that such outbreaks, under certain conditions, may be stopped.



FIG. 10.—Winged female of the "green bug," parasitized by *Lysiphlebus tritici*. Enlarged. (Original.)

In summing up these field experiments, then, it is found that these spots may be treated successfully either by plowing under and harrowing and rolling the surface of the ground, by spreading straw over them and burning, or by treating with a 10 per cent solution of kerosene emulsion. Except in the southernmost regions infested by this pest, however, the greatest difficulty does not arise from these isolated colonies, which seem to extend outward day after day, but from the fact that, after their food supply has become either largely destroyed or the grain too old and tough for them to feed upon, immense swarms of winged adults are produced, and these drift, in general, northward with the advance of the season and infest the grain fields of entire sections of the country much earlier and more completely than would be possible from the scanty stock natively present. This habit is also seen in the behavior of the pest in its original home in Europe. It may therefore prove that the country north of the Red River may be more or less protected if the pest can be early overcome in northern Texas.

AGRICULTURAL METHODS OF CONTROL.

The fact that the "green bug" in the South originates in spots in the grain fields has been alluded to, and also that from these fields come the vast swarms of winged females that develop and drift over the country, dispersing themselves in uninfested fields. Early sown fields or fields overgrown with volunteer grain seem especially to invite early attack in the more southern localities. Where these immense swarms settle down in a section of country, even the best fields of grain may succumb to their attacks. But usually, outside of an extremely limited area, there is a noticeable difference in intensity of attack as between different fields. In Oklahoma and northward, fields that have been late sown or that were pastured during the winter suffered worst and were the first to be destroyed. It has been frequently noticed that a field of grain may be totally destroyed, while an adjoining field, though seriously injured, will frequently produce a partial crop. An investigation of the history of these fields has invariably shown that the result in the latter case is due to fertile soil, proper cultivation, and seeding at the proper time. It seems to have been almost universally true, outside of the limited area of total destruction, that the best farmed fields have suffered the least. This does not apply alone to wheat, as the writer observed a field of oats near Hutchinson, Kans., that gave promise of a fair yield, where almost the entire crop would otherwise have been destroyed. The owner of this field, who had been obliged to plow up other fields where the cultural methods had been the same, expressed his opinion

that the reason the one field escaped the attack of the "green bug" to such an extent was that it had been for many years in alfalfa, only one crop, and that corn, having been taken from it since alfalfa had been turned under. He stated that the "green bug" was at one time as abundant in this field as in the ones which he had been obliged to plow under, but that in the one case the plants had withstood the attack better and were in better condition when the "green bugs" were overcome by the parasites, and thus able to start growth anew and yield to the owner a fair percentage of a crop.

In extreme western Kansas a field of 10 acres of oats lying adjacent to an irrigating ditch, but which had not been irrigated, showed very forcibly the effect of irrigation. Along this irrigation ditch was a ragged border of vigorously growing oats from 10 to 30 or 40 feet in width where the "green bug" had seemingly done no injury. Beyond this, where the moisture from the irrigating ditch had not penetrated, the loss was total. In another case in the same locality a part of the wheat in an unirrigated field came up in the fall and the rest not until spring; the former was uninjured by "green bugs," while the latter was killed. While late sowing in Texas will probably lessen attack in the fall, it is doubtful if this can be recommended north of the Red River. November-sown wheat was certainly less affected than others in North Carolina.

THE PRESENT "GREEN BUG" SITUATION IN THE SOUTHERN STATES,
MAY 1, 1909.

The situation over the country with reference to a future invasion of this pest, though not alarming, is sufficiently serious to render a word of warning exceedingly appropriate. In widely separated localities from Western North Carolina to eastern New Mexico the insect has become sufficiently abundant during March and April to work considerable injury locally. This shows that the pest has recovered from the severe reverse given it by its natural enemies in 1907, and that a repetition of the mild winter of 1908-9 and the present cold, backward spring will be almost certain to precipitate a more or less disastrous invasion. Of course no one knows what the winter of 1909-10 and the spring of 1910 will be, but it stands the grain growers in hand throughout the country south of Virginia, Kentucky, Missouri, and Kansas to destroy, as far as possible, all volunteer grain coming up in the fields during the coming autumn; and where fall oats are sown, as is generally the case throughout this country, the sowing should be delayed as late as possible. These two measures have a tendency to prevent the pest from becoming so thoroughly established in the grain fields during the autumn months, and

are the only measures that can be taken that will have a tendency to ward off an impending invasion.

We have found that where serious damage has been done to fields of grain in late winter and spring such fields had become seriously infested during the preceding autumn. The carrying out of these measures in the southern portion of the country has a tendency to protect the grain fields farther north, for we have had additional illustration of the fact that winged individuals are, during the spring months, being almost continuously carried northward by the wind.

It is somewhat a question as to whether the spring-sown oats farther north would suffer to a less degree if there were no invasion in the South in fields of fall-sown grain, both of oats and wheat. While it is not possible for an insect to make its way or be carried by the wind from Texas to northern Kansas, Missouri, southern Illinois, Indiana, and Ohio, nevertheless continuous breedings to the southward certainly do influence the numbers over this last-mentioned territory.

If the farmers of the country, instead of being carried away by the highly colored newspaper reports of the effect of the introduction of a few parasites in their fields, will seek to evade the pest by the destruction of volunteer grain in the fall and late sowing in the extreme South and turn their attention to better farm methods, including not only cultural methods but by all means rotation of crops, watching for and stamping out the pest when it first appears in the South in the fall and winter, they will in all probability suffer far less from destruction of their crops when the next invasion of this pest occurs.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *April 27, 1909.*

[Cir. 93]

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United States Department of Agriculture,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

THE CAUSE OF AMERICAN FOUL BROOD.¹

By G. F. WHITE, Ph. D.,

Expert in Bacteriology.

For several reasons much confusion exists as to the present status of our knowledge of bee diseases. It is hoped that this circular will give information which will to some extent clear up the subject of American foul brood from a bacteriological point of view. The symptoms of this disease are given in Circular No. 79 of the Bureau of Entomology, entitled "The Brood Diseases of Bees." American foul brood is the prevalent disease in America, and, judging from reports received from Europe and from descriptions in European bee journals and books, it is the prevalent one there. There is another diseased condition, which Cheyne examined, and to which we now refer as European foul brood.

When the author began his work on bee diseases in the summer of 1902 he observed, in combs containing American foul brood, in the dried remains of the dead larvæ, known as the scales, a very large number of spores which failed to grow when inoculated into the media ordinarily used in the laboratory. It was clear, then, that these spores are not *Bacillus alvei* and that this disease is not the "foul brood" of Cheshire and Cheyne. The following year the study was continued and a medium was devised in which the spores found in this disease will germinate. This medium consists of an agar made by following the directions ordinarily used in the laboratory, with the exception that bee larvæ are substituted for meat. By the use of this medium were obtained pure cultures of the microorganism which is found so abundantly, in the form of spores, in the dried scales of American foul brood.

In reporting these findings the author referred to this organism as "*Bacillus X*." Further study was subsequently made, and the species was given the permanent name *Bacillus larvæ*. The description of this species may be found in Technical Series No. 14 of this Bureau. In his publications the author has made no claim that *Bacillus larvæ* is the cause of American foul brood, but has made the statement that it is found to be present in all the samples of this disease which have

¹ The author wishes to acknowledge the assistance of Dr. E. F. Phillips, in Charge of Apiculture, under whose direction this work has been done. These results have been reached since the author has been connected with the apicultural investigations of the Bureau of Entomology.

been examined by him. No inoculation experiments were made, for the reason that sufficient cultures in suitable condition could not be obtained from any medium then known.

Since the media used in former investigations are not suitable for obtaining cultures for purposes of inoculation, in taking up the further study it has been necessary to devise a medium which would be satisfactory in this respect. Such a medium has been discovered, and large amounts of the culture suitable for experimental inoculations have been obtained. This medium is prepared and used as follows: Healthy bee larvæ or young pupæ are picked from the comb, crushed, strained through cheese cloth, diluted with 20 to 50 times their volume of water, filtered through ordinary filter paper, and then passed through an earthenware filter (the Berkefeld filter is satisfactory) to remove any bacteria which are present. The sterile filtrate thus obtained may be pipetted into tubes or flasks and stored until needed. When *Bacillus larvæ* is to be isolated, a tube of the ordinary agar of the laboratory is liquefied and cooled to 45° or 50° C. Then about 2 c.c. of the filtrate mentioned above is added to it. A very small amount of the decaying larvæ affected with American foul brood is then added. The procedure from this point is as usual in making agar plate cultures; these plates are afterward incubated. When a large amount of culture is desired for experimental purposes it is convenient to use the ordinary agar medium in large test tubes to which has been added, as above, about 2 c.c. of the sterile larvæ filtrate. These agar tubes are then inclined and the surface of the congealed agar is inoculated. In no case should the larvæ or filtrate reach a high temperature. The object, of course, is to obtain a medium which contains the food constituents which are afforded the bacteria in the living larvæ.

Inoculation experiments have been made by feeding to a healthy colony the scales from combs which had contained brood affected with American foul brood. The result of the feeding was that the colony became affected by disease, the symptoms of which were the same as those observed in the apiary where American foul brood is found. Like symptoms have been produced by feeding scales which had been put into ordinary meat bouillon, incubated for twenty-four hours, and then heated to 65° C. for twenty minutes.

On microscopic examination of the decaying larvæ dead from the disease thus produced experimentally, the same large number of spores and rods are seen as when samples are examined which are taken from an apiary affected with American foul brood. From these dead larvæ pure cultures of *Bacillus larvæ* were obtained from plates, using the new medium described above. These experiments show that by the feeding method the disease may be produced and that the contagion is found in the scales. The second experiment tends to indicate that the

cause of American foul brood as found in the scales is not killed by heat at 65° C. applied for twenty minutes.

Up to the present time there is no authentic record of this disease having been produced by experimental inoculations of pure cultures.

Knowing that by the feeding method the disease may be produced, pure cultures of *Bacillus larvæ* have been mixed with sterile sugar sirup and fed to healthy colonies with the result that the disease appeared in the colonies within three weeks with symptoms identical with those produced by feeding the scales of the disease. In the ropy brown mass of the decaying larvæ in the disease which is produced experimentally by feeding pure cultures of *Bacillus larvæ* there are found the same large number of spores and rods as when the disease is produced by feeding the scales or when the disease is found in an apiary. Pure cultures of *Bacillus larvæ* have been obtained from the larvæ dead from the disease produced experimentally by feeding pure cultures of *Bacillus larvæ*.

Some European investigators of brood diseases omit the symptoms, so that it is impossible to tell which disease they are investigating. Their descriptions of microorganisms also are entirely too brief. These facts have led to much confusion, and they necessitate much additional work on the part of other investigators. They have also added to the present confusion. From what can be gained from their papers, the author is inclined to believe that Burri has been working with *Bacillus larvæ* and has been referring to it as the "bacillus difficult of cultivation;" that Maassen has been working with *Bacillus larvæ* and has been referring to it as *Bacillus brandenburgiensis*, and that von Buttel Reepen has referred to *Bacillus larvæ* as "*B. burri*." It is hoped that this confusion may soon cease to exist.

In the study of *Bacillus larvæ* on this new medium some interesting additional facts have been observed in the morphology and cultural characters of this organism which will be given in a bulletin from this Bureau in the near future. One fact is mentioned now because it seems to have caused one German investigator, Dr. Albert Maassen, to fall into error in the interpretation of certain findings. This fact is that this species, *Bacillus larvæ*, produces a large number of giant whips. (Giant whips are at present believed to be in some way a modification of flagella, the motile organs of bacteria.) These giant whips appear in pure cultures of *Bacillus larvæ* and persist there for a long time. The structures which Maassen evidently saw and reported in two different publications, naming them *Spirochaeta apis*, are nothing other than giant whips which normally belong to *Bacillus larvæ* and which are formed by the growth of *Bacillus larvæ* in the larvæ of the bee.

Maassen seems to have no further evidence that the structures which he saw are spirochètes than what could be gained by a microscopic examination of the remains of the dead larvæ which had suffered from

this disease. The appearance which he interprets as a spirochæte in the process of division can be seen in the giant whips obtained from pure cultures of *Bacillus larvæ*. These giant whips are found in the decaying larvæ which are dead from American foul brood experimentally produced by feeding pure cultures of *Bacillus larvæ*.

The author has observed these structures in a large number of examinations of American foul brood, especially in the hanging-drop preparations made directly from the dead larvæ. There is nothing else contained in the dead larvæ which can be seen that resembles a spirochæte, and since Maassen made no mention of the giant whips found there so abundantly, it is quite certain that he has made this mistake.

This preliminary note will be followed by a bulletin which will contain in full the results of recent investigations by others on the brood diseases of bees and a detailed account of the work done here.

The results may be summarized as follows:

(1) In previous publications the author has made no claim that *Bacillus larvæ* is the cause of American foul brood.

(2) A medium has been devised by which cultures of *Bacillus larvæ* may be obtained in large quantities suitable for experimental inoculation. This medium consists of the sterile filtrate obtained by diluting and filtering the crushed bodies of bee larvæ through a Berkefeld or other fine filter.

(3) American foul brood has been produced by feeding pure cultures of *Bacillus larvæ*, and the symptoms of the disease are the same as those produced by feeding the scales of this disease and as those observed in the apiary where colonies are affected with this disease.

(4) The structures described by Doctor Maassen, of Dahlem, Germany, as spirochætes and named by him *Spirochæta apis* are not spirochætes, but normal structures produced by the growth of *Bacillus larvæ*. These are known in bacteriology as giant whips.

Approved:

W. M. HAYS,

Acting Secretary of Agriculture.

WASHINGTON, D. C., July 15, 1907.

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

**THE MOST IMPORTANT STEP IN THE CONTROL OF THE
BOLL WEEVIL.**

By W. D. HUNTER,

In Charge of Southern Field Crop Insect and Tick Investigations.

Damage by the boll weevil during the present season (1908) has one very peculiar feature. Except in the southern third of the total infested area the damage by this insect has been considerably less than normal. This situation was caused principally by very exceptional climatic conditions in the fall of 1907 which reduced greatly the numbers of weevils that passed through the winter. As these peculiar conditions did not extend to the southern limits of the weevil-infested area, the crop has been cut very short in southern localities both in Texas and Louisiana. With normal conditions during the coming fall and winter the weevil problem will be as serious everywhere next year as it has been in the southern regions during the present season. This circular points out exactly how planters can avert such a catastrophe. Now is the time to prepare for the crop of next season.

It has been repeatedly pointed out in publications of the Department of Agriculture that the most important step in controlling the boll weevil is the removal of the plants from the field as early as practicable in the fall. This was one of the original suggestions made by the Chief of this Bureau when the boll weevil was confined to a comparatively small area in Texas. Much subsequent work has shown the value of the original recommendation. Unfortunately the process of fall destruction of plants for controlling the boll weevil has been taken up but slowly by the planters. This is largely on account of the practical difficulties relating to the tenant system, and the scarcity of labor which has interfered with picking out the crop.

The agitation of the necessity for procuring an early crop in order to avoid damage by the cotton boll weevil has been carried on to such an extent by the Department of Agriculture that the details have become common knowledge. There is, however, a tendency on the part of many planters to lose sight of the fact that procuring an early crop is but one step, and is strictly secondary to the great essential step, namely, the destruction in the fall of the plants in the field. As a matter of fact, early planting, the use of early varieties, and the use of fertilizers are simply to further the advantage gained by the process of fall destruction.

A PRACTICAL ILLUSTRATION.

In the fall of 1906 the Bureau of Entomology conducted a large practical field test of the effectiveness of fall destruction of the plants in the control of the weevil. An isolated locality was found in Texas where over 400 acres of cotton were grown. There was no other cotton grown

in any direction nearer than 15 miles. Through an agent of the Bureau, Mr. J. D. Mitchell, to whom great credit is due for the direct management of the matter, arrangements were made by contract with the farmers concerned, under which all the cotton plants were uprooted and burned during the first ten days in October. Provision was also made to prevent the growing of volunteer or sprout cotton. In this way an opportunity was obtained for an ideal experiment to show what can be accomplished by the procedure that is now recommended by the Department. About 15 miles from the locality in which the experiment was performed a considerable quantity (295 acres) of cotton was grown. In this region the stalks were not destroyed in the fall, and observations made here have been used as a check upon the experimental area. The class of farmers is about the same in the two localities. The experiment was performed at Olivia, in Calhoun County, Tex., and the cotton utilized as a check was located at Six Mile, a settlement across Lavaca Bay, in the same county.

Mr. Mitchell visited the Olivia and Six Mile localities early in May, 1907. At that time, in the former area, extensive search revealed but a single weevil. In the Six Mile locality, however, the weevils were so numerous that practically all the squares had become infested. Other examinations were made, all of which showed the same advantage in regard to freedom from the weevil of the area in which the stalks were destroyed. On August 20 Mr. Mitchell found an average of over 10 bolls per plant at Olivia and only 3 bolls per plant in the check area.

The conspicuous results of the experiment, however, are revealed by the increased yield shown after the cotton was picked. The average in all fields at Olivia was 0.41 bale as against 0.15 at Six Mile. This increase of slightly over a quarter of a bale per acre (to be exact, 0.26 bale) was due to the destruction of the stalks. In order to determine the exact financial advantage to the farmers at the Olivia locality, a calculation has been made on the basis of the separate sale of lint and seed. At Olivia the crop following the destruction of the plants averaged 615 pounds of seed cotton per acre, that is, 205 pounds of lint and 410 pounds of seed. At the Six Mile settlement the average yield of seed cotton per acre was 225 pounds, that is, 75 pounds of lint and 150 pounds of seed. It is evident that the work done in the destruction of the plants at Olivia resulted in the gain of 130 pounds of lint and 260 pounds of cotton seed per acre. On the basis of a value of 10 cents per pound for the lint and of \$12 per ton for the seed, the increase amounted to \$14.56 per acre. This is about 29 times the cost of uprooting and burning the plants the preceding fall, as shown by the actual amount the Department paid for the work.

The full importance of the results just mentioned can not be realized until it is understood that the soil at Olivia is much less fertile than that at Six Mile. Mr. Mitchell, who is thoroughly familiar with the productiveness of lands in that part of the State, estimated that the Six Mile land is at least a third more fertile than that at Olivia. This estimate was more than borne out by the amount of seed produced at the two places during the season of 1907. At Six Mile the average height of the plants, determined by measuring, was 4 feet, while at Olivia the average was 2.2 feet. The estimate recorded of the advantage resulting from the work at Olivia is made without reference to this difference in fertility.

The practical experiment, as has been stated, returned substantially 29 times the cost of the necessary outlay. Under other conditions this advantage would necessarily be smaller. The experiment was carried on purposely to show the great advantage of fall destruction where there are no other factors to interfere with the results. Where cotton is less isolated than that at Olivia there will be less effective results, of course, on account of the influx of weevils from fields that may not have been properly treated. Nevertheless, such conditions could not possibly obliterate all effectiveness. In fact, only the most extreme and exceptional conditions could possibly result in reducing the advantage obtained in the experiment by more than 50 per cent. That means that any cotton planter, by the process of fall destruction, can insure himself an increased yield to the value of from \$5 to \$10 per acre by a small amount of work at the proper time in the fall.

REASONS FOR THE DESTRUCTION OF THE PLANTS IN THE FALL.

There are four principal reasons why the process of fall destruction recommended in this circular should be practiced universally by planters in infested regions:

First.—Fall destruction prevents absolutely the development of a multitude of weevils which would otherwise become adult within a few weeks of the time of hibernation. The destruction of the immature stages of weevils in infested squares and bolls is accomplished, while the further growth of squares, which may become infested later, is also prevented. This stops materially the development of weevils which would normally hibernate successfully, and by thus decreasing the number of weevils which will emerge in the spring the chances for a successful crop the following season are very greatly increased.

Second.—A proper manipulation of the stalks will bring about the destruction of a great majority of the weevils which are already adult. This will be accomplished partly by causing the starvation of many weevils before the natural time for hibernation, and partly by exposure to severe cold during the fall and winter.

Third.—It has been shown conclusively that the bulk of the weevils which survive the winter are those which reach maturity late in the season. It is evident that the weevils that pass the winter and attack the crop of the following season are among those developed latest in the fall and which, in consequence of that fact, have not exhausted their vitality by depositing eggs for any considerable length of time. Fall destruction of the plants, increasing the length of the hibernating period, reduces many fold the number of weevils in the fields that would otherwise emerge in the spring to damage the cotton.

Fourth.—Clearing of the field in the fall makes it possible to practice fall plowing, which is not only the proper procedure in any system of cotton raising, but also greatly facilitates the early planting of the crop the following spring. The ground becomes clean by this practice, so that but few places for shelter are left to the weevils, and various climatic conditions still further reduce the number of the survivors.

DATA UPON WHICH THE FOREGOING REASONS ARE BASED.

The reasons for fall destruction given above are based upon a very large amount of data from actual experiments and the work of various planters. The information at hand was greatly amplified in a series of

large-scale experiments carried on during the winter of 1906-7. Three large cages (50 by 20 feet) were built over growing cotton at Dallas, Calvert, and Victoria, in Texas. In different compartments of these cages nearly 70,000 weevils were placed; several thousand in each compartment. After the weevils were placed inside, the plants were removed from the first section about the middle of October. At regular subsequent dates other sections were treated in exactly the same manner. Consequently the results for each locality show exactly what a farmer could have accomplished by the destruction of the plants at different times. The full results will be published in Bulletin 77, of this Bureau, by Dr. W. E. Hinds and Mr. W. W. Yothers, who have had direct charge of the work. In this connection it is necessary to call attention to only a few features.

In practically all cases the smallest survival of weevils was found in those cages from which the plants were removed at the earliest dates, and the number of survivors increased regularly as the dates of destruction became later. For instance, at Dallas out of between two thousand and three thousand weevils in each cage, only 2.5 per cent survived when the plants were removed on October 13; 4 per cent survived destruction of the food supply on October 16; 6.2 per cent survived destruction on October 19; 12.2 per cent survived destruction on November 6, and 14.7 per cent survived destruction on November 12. *These figures indicate that practically seven times as many weevils survived after destruction of plants on November 12 as survived after a similar destruction on October 13. This is a most striking illustration of the effect of early destruction.*

In the cages at Dallas, Calvert, and Victoria, from which the plants were removed in November, 14.26 per cent survived, while 4.41 per cent survived removal of the plants in October—that is, the cutting off of the food supply in November resulted in the survival of three times as many weevils as survived when the work was done in October. These figures are based upon averages of eight large cages at the three localities in which October destruction took place, as compared with seven similar cages in which the plants were removed in November.

TIME FOR DESTRUCTION OF THE PLANTS.

It is naturally impossible to fix any date for the destruction of the stalks which would apply to all localities and under all conditions. The condition of the soil must be considered as well as the maturity of the crop. While the condition of the soil can not be controlled, the time of the maturity of the crop, except in extremely unfavorable seasons, is largely within the power of the planter, since by early planting of early maturing varieties the entire crop may be matured before the usual time of picking of the first cotton from native seed. Nevertheless, whatever modifications are necessary in different localities and during different seasons, they do not decrease the general strength of the recommendations.

The proper time for the destruction of the plants in the fall is whenever the weevils have become so numerous that there is no prospect that any more cotton will be made. It will be an easy matter for any planter to determine this point by an examination of a few plants in his field. Whenever it is found that all, or nearly all, of the squares and some of the bolls are being punctured, there is no hope for pro-

ducing any more cotton. The farmer should then wait until the bolls already set on the plants have opened, and destruction should then take place immediately.

The rule should consequently be that the plants should be destroyed in the fall whenever all or practically all of the fruit is being damaged, regardless of whether this is in September or November. In the great majority of cases in Texas and in Louisiana the month of October would be the proper time. In many cases earlier destruction could and should be practiced. Nevertheless, it should not be thought that fall destruction will be useless after the time mentioned. Even until much later many weevils in the remains of bolls hanging to the plants may be destroyed, but the process loses in value the longer it is deferred. By all means, if possible, the destruction of plants should take place before frost, but destruction after frost, though not nearly as efficacious as earlier destruction, should always be practiced when it has not been possible to remove the plants previously.

METHOD OF REMOVING THE PLANTS.

The common practice of removing the cotton stalks from the fields by the use of the stalk cutter (a wheeled cylinder provided with knives) is not effective in the fall destruction that should be practiced to avoid damage by the boll weevils. The stalks remaining in that case during mild weather give rise to sprouts, which furnish an abundance of food to weevils that would otherwise starve. Moreover, the fact that this machine cuts the stalks into short pieces makes the necessary collection of them difficult.

There are two effective methods of removing the plants from the ground. One of these, the method to be preferred, is to cut the roots 2 or 3 inches beneath the surface by the use of an ordinary plow. The other is to pull out the stalks by the use of a lever provided with a toothed notch which grasps the base of the plant. The latter process is better adapted for use when the plants have been killed by frost. When they are still green, or the ground is dry, it is frequently a difficult matter to remove them with these levers. The Department's general recommendation, therefore, is that the plants should be plowed out. As soon as possible after this is done they should be collected by hand or by means of rakes and brought together in large heaps or windrows. It is very important that this collection should take place before the leaves have become dry and have dropped off. When the plants are carried to heaps immediately after uprooting, all of the leafage, which will dry in a few days, remains to facilitate the burning of the stalks.

After the stalks have become dry enough they should be burned. If the weather be fair, this can be done in about two weeks. If rains cause a lengthening of this period, it would undoubtedly be worth the cost to the planter to purchase crude oil sufficient to bring about the complete burning of all the stalks.

It is not considered necessary to leave any trap rows to attract such weevils as may have escaped the burning. The weevil seems to have but little tendency to be attracted to such plants. After the destruction of the main crop the spread would probably be in all directions and the numbers collected on the trap rows would consequently be inconsiderable. The time and expense of properly carrying on the

hand picking of the weevils and infested fruit on trap rows would be a considerable handicap to the method on many plantations. Nevertheless, on small places where suitable labor is abundant, traps could conveniently be left. In such cases they should be situated on those sides of the fields which are generally leeward. They should be examined daily for weevils and infested squares and bolls, which should be immersed in crude oil. After such collection for ten days, the trap plants should be uprooted and burned immediately with the aid of crude oil.

The suggestion has been made at various times that grazing the cotton fields with cattle is in some cases equivalent to destruction in the way that has been suggested. However, in many parts of the infested area there are not sufficient cattle to accomplish the work, and, moreover, in very many fields the cattle, by disseminating Johnson grass and other plant pests, would undoubtedly do more harm than good. At the same time the most thorough grazing always leaves a few green sprouts or leaves upon which weevils may feed, and of course leaves the stalks standing, so that the process of leafing, for the benefit of the weevils, may continue indefinitely. Where the condition of the fields permits and the supply of cattle is sufficient, grazing the fields should be practiced, but this can not generally be the case in the infested area.

DIFFICULTIES.

The Department of Agriculture understands that there are some difficulties in the way of a universal following of the recommendations given in this circular. The principal ones are the almost universal hope for a top crop and in the labor conditions consequent from the more or less universal tenant system of producing the staple. These difficulties are increased by the general scarcity of labor in the South, which is becoming more and more a serious problem in raising cotton.

Planters in infested localities must understand that with the presence of the weevil there is no longer any hope of a top crop. It is true that after considerable cotton has matured, and after the plants have applied their energy to the formation of seeds and lint, fall rains often stimulate the production of a great number of squares. Many planters are misled by this into the hope of gathering a large top crop. The joints of the plant are short and the squares are formed rapidly and close together. Though weevils may have been exceedingly numerous in the fields, the presence of this abundance of food causes them to scatter, and they are consequently temporarily somewhat less in evidence. In many cases blooms appear and the hope for a top crop increases. Nevertheless, this production of squares also contributes to the production of a large number of weevils late in the season and just at the time for their successful hibernation. As a result of this fact great injury is done to the crop of the following season, with no gain whatever, or a very small one, in the yield of the current season. From these considerations it seems plain that within the weevil territory all hope of a top crop must be given up and the destruction of the plants be practiced as early in the fall as possible.

Another important difficulty lies in the tenant system. It is usually the practice to terminate the work of the tenant with the picking of the cotton, leaving the clearing of the field for the next cropper. At present, after the cotton is picked the tenants frequently move to other planta-

tions or to other parts of the same plantation. It should not be a difficult matter for planters to induce their tenants to practice the fall destruction of the plants as the last step in the production of a crop. In any case the plants have to be removed before the ground can be prepared for planting the following season; and the present recommendation merely involves applying, at a time some months earlier, the same amount of labor as is necessary in the spring. The best solution of the difficulty arising from the tenant system would be in the inclusion, in the agreement between the landlord and the tenant, of a provision which would bind the latter to clean the land thoroughly before leaving it.

In a comparatively small area in southwestern Texas it might be considered that there would be a further objection in the practice which some farmers have of encouraging the growth of volunteer or seppa cotton in the hope of procuring an early and inexpensive crop. As has been repeatedly pointed out by the Department of Agriculture, this is beyond question the worst possible practice in weevil-infested regions. The disastrous experience of several counties in the southern portion of the State during several seasons has abundantly demonstrated the force of the warnings that have been issued from time to time. The staple produced by volunteer plants is short, kinky, and undesirable. Before the advent of the weevil the only reason for encouraging such growth was to procure the first bale. Now, on account of its very detrimental bearing on the weevil problem, any attempt to raise cotton from volunteer cotton should by all means be discouraged.

The point may be raised that the burning of the plants in the fall removes valuable fertilizing constituents and that the continuance of the practice would seriously reduce the fertility of the soil. In reference to this matter, however, it must be stated that the present general practice is to clear the fields by burning the plants in the spring. Therefore, practically the only additional draft upon the soil by the method recommended is in the burning of many of the leaves and a portion of the roots. However, destruction of the plants can only take place after many of the leaves have fallen, and, in other cases, when the plants have become completely defoliated by the cotton caterpillar. The fertilizing constituents in various parts of the cotton plant have been carefully determined.¹ An estimate of the value of all the constituents which could possibly be removed by fall destruction, based upon the schedule of trade values adopted by experiment stations for 1898, shows that the loss per acre would be very small. It is plain that the planter could not only regain this small loss but actually greatly increase the fertility of the land by the use of commercial fertilizers, which would cost an inconsiderable amount in comparison with the gain in the following crop, as a result of lessened damage by the boll weevil. In some cases, of course, the removal of humus furnished by the stalks may be more important than the removal of the fertilizing elements. It is urged, however, that the cheapest and most effective way to add humus to the soil is by green manuring, which is receiving more and more attention throughout the cotton belt.

As a matter of fact, the preceding objections are not necessarily serious. They deal with general changes in cotton culture made neces-

¹ See Bulletin 33 of the Office of Experiment Stations of this Department, pp. 81 to 142.

sary by the ravages of the boll weevil. As is beginning to be well known to planters, it will not be possible for tenants to work as much land as formerly. More cotton will be produced by decreasing acreages and increasing the attention given to what remains. If this is done the objections mentioned will largely disappear.

CONCLUSION.

Having studied and tested the methods of weevil control which have been hitherto recommended, the writer firmly believes that the destruction of the stalks in the early fall is the most effective method known of actually reducing the numbers of the pest. This destruction will cost but a small fraction of the expense necessary in the frequent picking up in the spring of the squares infested by the hibernated weevils, and is far more thorough as a means of reducing the numbers of the weevil than is the practice of picking hibernated weevils from the young plants. Early destruction of the stalks is essential to the greatest success of any system of controlling the pest. All other practices recommended, though very valuable in securing a crop, are of the greatest value as they are followed in connection with this one prime essential. Since the earliest investigations of the boll weevil made by this Department, it has been recognized and pointed out by Dr. L. O. Howard that this practice is of the first importance, and the experience of recent years has added but certainty to this conviction. A number of planters have adopted it, and their work and the large-scale work by the Bureau of Entomology have abundantly demonstrated its effectiveness. *It must not be thought that the procuring of the immediate crop is the only thing to be desired. Early and complete destruction of the stalks is undoubtedly the most important single element insuring success for the subsequent year.*

Concerted action in fall destruction is, of course, desirable. The greatest benefit will result only when whole communities adopt the method. But no planter should hesitate on account of the indifference of his neighbors. The fact that weevils move about but little until the time when the bulk of the crop is safe will assist materially in saving one field though near-by ones have not been properly treated, and even under such circumstances the success of the method in one field will be a powerful stimulus toward its general adoption the following season.

It is true that the recommendations contained in this circular involve considerable change in the culture of cotton. Nevertheless the important changes that have been brought about, up to this time, in the use of improved seed and fertilizers have also been revolutionary in their character. It is hoped by the Department that the agencies assisting in this matter—namely, organizations of business men—will everywhere devote the same energy toward encouraging the practice of what is, after all, the most important step in maintaining the supremacy of the cotton crop in the weevil territory.

Approved :

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., September 3, 1908.

Département de l'Agriculture des États-Unis,

BUREAU D'ENTOMOLOGIE,

L. O. HOWARD, Entomologiste et Chef de Bureau.

A PLUS IMPORTANTE MESURE À PRENDRE CONTRE LE BOLL-WEEVIL (LE CHARANÇON DE LA BALLE DU COTON).

Par W. D. HUNTER,

Chargé des investigations concernant les insectes des récoltes du Sud et les tiques.

Les ravages causés par le boll-weevil pendant la présente saison (1908) ont un aspect tout spécial. Sauf sur le tiers méridional de l'étendue totale infestée, les ravages causés par cet insecte ont été bien au-dessous de l'ordinaire. Cet état est dû principalement aux conditions climatériques toutes exceptionnelles de l'automne de 1907 qui ont grandement réduit le nombre des weevils ayant résisté à l'hiver. Comme ces conditions particulières ne se sont pas étendues aux limites méridionales de la superficie infestée par le weevil, la récolte en a été très diminuée dans les localités méridionales et du Texas et de la Louisiane. Si les conditions sont normales pendant l'automne et l'hiver prochains, le problème du weevil sera partout aussi sérieux, l'année prochaine, qu'il l'a été dans les régions méridionales pendant cette saison. Cette circulaire indique exactement aux planteurs la manière d'éviter une pareille catastrophe. Nous sommes au moment où il faut prendre ces mesures pour la récolte de la saison prochaine.

On a souvent indiqué dans les publications du Département de l'Agriculture que le moyen le plus important dans la lutte contre le boll-weevil consiste à enlever du champ les plantes aussitôt que possible en automne. Cette idée est l'une des premières que suggéra le Chef de ce Bureau, alors que le boll-weevil n'existait que sur une superficie relativement peu considérable du Texas. Beaucoup de travail accompli subséquemment a démontré la valeur de ce premier conseil. Malheureusement les planteurs n'adoptèrent que lentement le procédé de destruction automnale des plantes destiné à arrêter les ravages du boll-weevil. Ce qui est dû en grande partie aux difficultés

^a Édition anglaise publiée le 21 septembre 1908.

pratiques concernant le système de louage (tenant system), et à la rareté de la main d'œuvre qui a mis obstacle à l'enlèvement de la récolte.

L'agitation créée par le Département de l'Agriculture pour convaincre de la nécessité qu'il y a à obtenir une récolte hâtive pour éviter les ravages du boll-weevil du coton a été poussé à un tel point que les détails en sont devenus de connaissance générale. Il n'en existe pas moins chez beaucoup de planteurs une tendance à perdre de vue ce fait qu'obtenir une récolte hâtive n'est qu'une seule mesure et est strictement secondaire à la mesure essentielle, la destruction automnale des plantes dans le champ. En fait, planter de bonne heure, employer des variétés précoces, et se servir d'engrais, tout cela n'a pour but que d'accroître les avantages obtenus par la destruction automnale.

UN EXEMPLE PRATIQUE.

Pendant l'automne de 1906 le Bureau d'Entomologie s'est livré à un essai pratique en grand—dans les champs—sur l'efficacité de la destruction automnale des plantes pour se rendre maître du weevil. On découvrit au Texas une localité isolée où se cultivaient plus de 400 acres de coton. Il n'existait aucune autre culture de coton en deçà de 15 milles. Par l'intermédiaire d'un agent du Bureau, M. J. D. Mitchell, auquel revient grand honneur pour la manière dont il a conduit l'affaire, des contrats furent passés avec les fermiers intéressés, conformément aux termes duquel toutes les plantes de coton furent arrachées et brûlées pendant les dix premiers jours d'octobre et une stipulation y fut faite ayant pour but de prévenir la pousse des rejets du coton ou des "volunteers." De cette manière on eut l'occasion de faire une expérience idéale destinée à montrer ce que peut accomplir le procédé actuellement recommandé par le Département. À 15 milles environ de la localité où était conduite l'expérience, se trouvait un champ de coton d'une surface considérable (295 acres). Dans cette région les chaumes ne furent pas détruits pendant l'automne, et les observations faites ici ont été employées comme champ de comparaison au champ d'expérimentation. La classe de fermiers est à peu près la même dans les deux localités. L'expérience a eu lieu à Olivia, dans le comté de Calhoun, Texas, et le coton employé comme champ de comparaison était situé à Six Mile, colonie établie sur l'autre rive de la baie Lavaca, même comté.

M. Mitchell visita les localités d'Olivia et de Six Mile dans les premiers jours de mai 1907. Des recherches étendues ne révélèrent alors, dans la localité d'Olivia, la présence que d'un seul weevil. Mais dans la localité de Six Mile les weevils étaient si nombreux qu'on peut dire que toutes les feuilles florales (squares) en étaient infestées. On

se livra à d'autres recherches qui toutes démontrèrent la même supériorité touchant l'absence du weevil sur la superficie où l'on avait détruit les chaumes. Le 20 août M. Mitchell trouva une moyenne de plus de 10 balles par plante sur le champ d'expérience à Olivia et seulement 3 balles par plante sur le champ de comparaison.

Bien plus, les résultats remarquables de cette expérimentation se trouvent révélés par l'accroissement de rendement que montra la récolte de coton. La moyenne des champs d'Olivia fut de 0.41 balle (bale) contre 0.15 à Six Mile. Cette augmentation d'un peu plus d'un quart de balle par acre (exactement 0.26 balle) est dû à la destruction des chaumes. Dans le but de déterminer exactement le profit pécuniaire en résultant pour le fermier de la localité d'Olivia, on fit un calcul basé sur la vente séparée du coton et de la graine. À Olivia la récolte qui suivit la destruction des plantes atteignit une moyenne de 615 livres de coton en graine par acre, c'est-à-dire 205 livres de coton et 410 livres de graine. À la colonie de Six Mile le rendement moyen de coton-graine par acre fut de 225 livres, soit 75 livres de coton et 150 livres de graine. Il est évident que le travail accompli dans la destruction des plantes à Olivia a donné un gain de 130 livres de coton et de 260 livres de graine de coton par acre. Si l'on se base sur une valeur de 10 cents par livre pour le coton et \$12 par tonne pour la graine, on trouve une augmentation de \$14.56 par acre. Ce qui représente environ 29 fois le coût du déracinement et du brûlage des plants accomplis l'automne précédent, ainsi que le prouve la somme payée par le Département pour ce travail.

On ne peut se faire une idée juste de toute l'importance des résultats qui viennent d'être mentionnés que si l'on se rend compte que le sol d'Olivia est beaucoup moins fertile que celui de Six Mile. M. Mitchell, qui est entièrement au courant de la productivité des terres dans cette partie de l'état, a estimé que la terre de Six Mile est d'un tiers au moins plus fertile que celle d'Olivia. Cette estimation a été plus que corroborée par la quantité de graine produite aux deux endroits pendant la saison de 1907. À Six Mile la hauteur moyenne des plants, déterminée en les mesurant, était de 4 pieds, tandis qu'à Olivia la moyenne était de 2.2 pieds. L'estimation consignée de l'avantage du travail accompli à Olivia est faite indépendamment de cette différence de fertilité.

L'expérimentation pratique, comme on l'a dit, a rapporté réellement 29 fois le coût des déboursés nécessaires. Dans des conditions différentes cet avantage serait nécessairement moindre. L'expérimentation fut faite dans le but exprès de montrer le grand avantage de la destruction automnale là où il n'existe point d'autres agents entravant les résultats. Là où le coton est moins isolé que celui d'Olivia, il y aura naturellement moins de résultats effectifs à cause de l'affluence de weevils venant de champs qui pourront n'avoir pas été

efficacement traités. Néanmoins, de pareilles conditions ne pourraient absolument point oblitérer toute efficacité. En fait, les plus extrêmes et les plus exceptionnelles conditions pourraient seules arriver à réduire de plus de 50 pour cent l'avantage obtenu dans l'expérimentation. D'où il résulte que tout planteur de coton, grâce au procédé de destruction automnale, peut s'assurer une augmentation de récolte d'une valeur de \$5 à \$10 par acre, au prix d'un peu de travail fait au bon moment en automne.

RAISONS POUR LESQUELLES ON DEVRAIT DÉTRUIRE LES PLANTES EN AUTOMNE.

Il y a quatre raisons principales pour que le procédé de destruction automnale recommandé dans cette circulaire soit universellement adopté par les planteurs des régions infestées.

Premièrement.—La destruction automnale prévient absolument le développement d'une multitude de weevils qui, sans cela, deviendraient adultes dans l'espace de quelques semaines avant le temps de l'hibernation. La destruction des phases d'immaturité des weevils dans les feuilles florales (squares) et balles infestées s'accomplit, et la croissance ultérieure de feuilles florales (squares) pouvant devenir infestées plus tard est également empêchée. Cela arrête sensiblement le développement des weevils qui, ordinairement, hiberneraient efficacement, et, en diminuant ainsi le nombre des weevils qui surgiront au printemps, les chances d'avoir une récolte fructueuse à la saison suivante se trouvent très grandement accrues.

Deuxièmement.—Une bonne manipulation des chaumes faite à propos amènera la destruction d'une grande majorité des weevils qui sont déjà adultes, destruction qui résultera, en partie, de ce qu'un grand nombre de weevils mourront de faim avant le temps naturel de l'hibernation et, en partie, de leur exposition au froid rigoureux pendant l'automne et l'hiver.

Troisièmement.—Il a été démontré d'une manière concluante que la plus grande partie des weevils qui survivent à l'hiver se compose de ceux qui atteignent la maturité dans la dernière partie de la saison. Il est évident que les weevils qui passent l'hiver et attaquent la récolte de la saison suivante sont de ceux qui se sont développés le plus tard en automne et qui, en conséquence de ce fait, n'ont pas épuisé leur vitalité en pendant des œufs durant un espace de temps considérable. La destruction automnale des plants, en accroissant la longueur de la période d'hibernation, réduit de beaucoup le nombre, dans les champs, des weevils qui, sans cela, surgiraient au printemps pour endommager le coton.

Quatrièmement.—En déblayant le champ en automne on rendra possible le labourage d'automne, ce qui est non seulement le vrai

procédé dans toute méthode de culture du coton, mais ce qui facilite encore grandement le semage hâtif au printemps suivant. Le terrain se trouve net par cet usage, de sorte qu'il ne reste aux weevils que peu d'endroits où s'abriter et diverses conditions climatiques réduisent encore plus le nombre des survivants.

DONNÉES SUR LESQUELLES SONT BASÉES LES RAISONS QUI PRÉCÉDENT.

Les raisons données ci-dessus en faveur de la destruction automatique sont basées sur une très grande quantité de données résultant d'expérimentations et sur les opérations de divers planteurs. Les renseignements obtenus se sont grandement accrus dans une série d'expérimentations faites sur une grande échelle pendant l'hiver 1906-7. On construisit trois grandes cages (50 pieds par 20) audessus de coton en croissance à Dallas, à Calvert, et à Victoria, dans le Texas. Dans différents compartiments de ces cages on mit près de 70,000 weevils; plusieurs milliers dans chaque compartiment. Après avoir placé les weevils dedans, on enleva de la première section les plantes vers le milieu d'octobre. À des dates subséquentes et régulières, d'autres sections furent traitées exactement de la même manière. Les résultats pour chaque localité montrent donc exactement ce qu'un planteur aurait pu accomplir par la destruction des plantes à différentes époques. Les résultats complets seront publiés dans le Bulletin 77 de ce Bureau, par le Dr. W. E. Hinds et M. W. W. Yothers, qui ont eu la direction du travail. À ce propos il n'est nécessaire d'appeler l'attention que sur quelques points.

Dans presque tous les cas ce fut dans les cages dont les plants avaient été enlevés le plus tôt qu'on trouva la moindre survivance de weevils, et le nombre des survivants augmentait régulièrement à mesure que les dates de destruction devenaient plus tardives. Par exemple, à Dallas, sur 2,000 à 3,000 weevils dans chaque cage, 2.5 pour cent seulement survécurent quand les plants furent enlevés le 13 octobre; 4 pour cent survécurent à la destruction de l'approvisionnement de nourriture du 16 octobre; 6.2 pour cent survécurent à la destruction du 19 octobre; 12.2 pour cent survécurent à la destruction du 6 novembre, et 14.7 pour cent survécurent à la destruction du 12 novembre. *Ces chiffres indiquent qu'en fait sept fois autant de weevils ont survécu après la destruction des plants du 12 novembre qu'il en a survécu après la même destruction du 13 octobre. Cet exemple montre d'une manière frappante l'effet de la destruction hâtive.*

Dans les cages à Dallas, à Calvert, et à Victoria, d'où les plants furent enlevés en novembre, 14.26 pour cent survécurent, tandis que 4.41 pour cent survécurent à l'enlèvement des plantes en octobre—

c'est-à-dire que la suppression de la source de nourriture faite en novembre permit la survivance de trois fois autant de weevils que la suppression faite en octobre. Ces chiffres sont basés d'une part sur la moyenne de huit grandes cages dans les trois localités où la destruction d'octobre eut lieu et, d'autre part, sur sept cages semblables dans lesquelles les plantes furent transportés en novembre.

ÉPOQUE FAVORABLE À LA DESTRUCTION DES PLANTES.

Il est naturellement impossible de fixer pour la destruction des chaumes une date qui convienne à toutes les localités et à toutes les conditions. Il faut tenir compte de l'état du sol aussi bien que du degré de maturité de la récolte. Quoique l'état du sol ne soit pas au pouvoir du planteur, l'époque de la maturité de la récolte, sauf dans des saisons extrêmement défavorables, dépend grandement de lui, puisque, en plantant de bonne heure des plantes de maturité précoce, la moisson entière peut mûrir avant l'époque ordinaire où l'on récolte le premier coton provenant de graine indigène. Toutefois, quelles que soient les modifications nécessaires suivant les localités et les saisons, elles ne diminuent point la force générale des recommandations.

Quel est le bon moment pour détruire les plantes en automne? C'est quand les weevils sont devenus si nombreux qu'il n'y a pas d'espoir d'obtenir encore du coton. L'examen de quelques plantes de son champ permettra facilement au planteur de décider ce point. Toutes les fois qu'on s'aperçoit que tous ou presque toutes les feuilles florales (squares) et quelques-unes des balles ont des piqûres, il n'est plus possible d'espérer encore du coton. Le fermier doit alors attendre que les balles existant sur les plantes se soient ouvertes, et c'est immédiatement alors que doit être faite la destruction.

La règle est donc de détruire les plantes en automne toutes les fois que tous ou presque tous les fruits sont endommagés, que ce soit en septembre ou en novembre. Dans la grande majorité des cas au Texas et dans la Louisiane, le mois d'octobre est le bon moment. Dans beaucoup de cas on peut et on doit opérer la destruction plus tôt. Toutefois, il ne faut pas croire que la destruction automnale soit inutile après l'époque dont il a été parlé. Il est même possible de détruire beaucoup plus tard un grand nombre de weevils dans ce qui reste de balles suspendues aux plantes, mais plus on ajourne le procédé, plus il perd de sa valeur. À tout prix la destruction des plants doit avoir lieu avant la gelée, si c'est possible, mais la destruction après la gelée, quoique bien moins efficace que celle opérée plus tôt, doit toujours se faire quand il n'a pas été possible d'enlever les plants auparavant.

MANIÈRE D'ENLEVER LES PLANTES.

La manière ordinaire d'enlever des champs les chaumes de coton au moyen du coupoir de chaumes (cylindre à roue pourvu de lames) n'est pas efficace dans la destruction automnale que l'on doit opérer pour éviter les ravages du boll-weevil. Les chaumes qui restent en ce cas donnent naissance, lorsque le temps est doux, à des rejetons, et ces rejetons fournissent une abondance de nourriture aux weevils qui, sans cela, mourraient de faim. De plus, comme cette machine coupe les chaumes en petits morceaux, il en résulte de la difficulté à les réunir et à les enlever.

Il existe deux méthodes efficaces pour enlever du sol les plants : l'une d'elles, celle qui doit être préférée, consiste à couper les racines à 2 ou 3 pouces au-dessous de la surface au moyen d'une charrue ordinaire ; l'autre consiste à arracher les chaumes au moyen d'un levier muni d'un cran qui saisit la base de la plante. Ce dernier procédé est d'usage plus facile quand la gelée a tué les plantes. Quand les plantes sont encore vertes ou que la terre est sèche, il y a souvent difficulté à les enlever avec ces leviers. La recommandation générale du Département est donc de les enlever avec la charrue. Cela fait, il faut, aussitôt que possible, les ramasser à la main au moyen de râtaux et les réunir en gros tas ou "windrows." Il est très important que ce dernier travail se fasse avant que les feuilles sèchent ou tombent. Si les plantes sont mis en tas immédiatement après qu'on les a déracinés, tout le feuillage sèche en quelques jours et reste pour faciliter le brûlage des chaumes.

Après que les chaumes sont devenus assez secs, il faut les brûler. Si le temps est beau, cela peut se faire environ deux semaines après. Si les pluies causaient la prolongation de cette période de temps, le planteur aurait tout intérêt à acheter de l'huile brute en quantité suffisante pour arriver à brûler complètement tous les chaumes.

On ne juge pas nécessaire de laisser des rangées comme pièges pour attirer les weevils qui peuvent avoir échappé au brûlage. Le weevil semble peu attiré vers telles plantes. Après la destruction de la récolte principale ils se répandraient vraisemblablement dans toutes les directions et le nombre réuni sur les rangées-trappes serait par conséquent peu considérable. Le temps et la dépense nécessités par le cueillage à la main des weevils et des fruits infestés sur les rangées-trappes seraient un obstacle considérable à cette méthode sur beaucoup de plantations. Néanmoins, dans les endroits de peu d'étendue, où la main d'œuvre compétente est abondante, on pourrait sans inconvénient laisser des trappes. Dans ce cas, il faudrait les situer sur les côtés des champs qui sont généralement sous le vent. Il faudrait aussi s'assurer chaque jour s'il se trouve des weevils et

des feuilles florales (squares) et balles infestées qu'on plongerait alors dans de l'huile brute. Après s'être livré à ce cueillage pendant dix jours, il faudrait déraciner les plantes-trappes et les brûler immédiatement à l'aide de l'huile brute.

L'opinion a plusieurs fois été émise, que faire paître le bétail dans les champs de coton équivaut, dans quelques cas, à la destruction par la méthode suggérée. Mais, dans beaucoup de parties de la superficie infestée il n'y a pas assez de bétail pour accomplir la besogne, et, de plus, dans un grand nombre de champs le bétail en disséminant l'herbe Johnson et autres plantes malfaisantes, ferait sans aucun doute plus de mal que de bien. En outre, la paissance la plus complète laisse toujours quelques rejets ou feuilles vertes où les weevils peuvent trouver à se nourrir et laisse naturellement les chaumes sur pied, de sorte que la pousse des feuilles peut continuer indéfiniment au profit des weevils. Là où l'état des champs le permet et où le bétail est assez nombreux on doit faire pâturer, mais ce ne peut être le cas général dans la superficie infestée.

DIFFICULTÉS.

Le Département de l'Agriculture sait qu'il existe quelques difficultés dans l'application universelle des recommandations contenues dans cette circulaire. Les principales sont l'espoir presque universel d'une moisson seconde (top crop) et l'état de la main d'œuvre résultant du système plus ou moins universel de fermage pour la culture de ce produit. Ces difficultés se trouvent augmentées par la rareté générale de la main d'œuvre dans le Sud, rareté qui devient de plus en plus un sérieux problème dans la culture du coton.

Les planteurs des localités infestées doivent bien se rendre compte que, avec la présence du weevil il n'y a plus à espérer une seconde récolte (top crop). Il est vrai que, après qu'une quantité considérable de coton est arrivée à maturité et après que les plantes ont employé leur énergie à la formation de graines et de coton, les pluies d'automne excitent souvent la production d'un grand nombre de feuilles florales (squares) et, par suite, un grand nombre de planteurs s'abandonnent à l'espoir de recueillir une abondance de seconde moisson. Les nœuds de la plante sont courts et les feuilles florales (squares) se forment rapidement et tout près les uns des autres. Bien que les weevils puissent avoir été extrêmement nombreux dans les champs, la présence de cette abondance de nourriture les fait se disperser, et, par suite, ils se trouvent provisoirement un peu moins en évidence. Dans beaucoup de cas des fleurs apparaissent et l'espoir d'une moisson seconde (top crop) s'accroît. Néanmoins cette production de feuilles florales (squares) contribue aussi à la production d'un grand nombre de weevils vers la fin de la saison et

uste à l'époque favorable à une heureuse hibernation de ces insectes. Il en résulte un grand dommage pour la récolte de la saison suivante, et aucun gain ou du moins un gain minime dans le rendement de la saison courante. De ces considérations il semble clairement résulter que dans la limite du territoire du weevil tout espoir d'une seconde moisson doit être abandonné et que la destruction des plantes doit être faite aussitôt que possible en automne.

Une autre difficulté importante réside dans le système de fermage. D'après la coutume générale, le travail du fermier finit avec le cueillage du coton, et le déblaiement du champ incombe à celui qui fera la récolte suivante. Actuellement, après le cueillage du coton, les fermiers se transportent souvent sur d'autres plantations ou sur d'autres parties de la même plantation. Il ne devrait pas être difficile pour les planteurs d'amener leurs fermiers à accepter la destruction automnale des plantes comme dernière mesure dans la production d'une récolte. Les plantes doivent, en tout cas, être enlevés avant que le terrain puisse être préparé pour l'ensemencement de la saison suivante; ce que nous recommandons c'est seulement d'accomplir quelques mois plus tôt la même somme de travail qui serait requise au printemps. La meilleure solution de la difficulté provenant du système de fermage serait d'insérer dans le contrat passé entre le propriétaire et le tenancier, une clause qui obligerait ce dernier à déblayer complètement la terre avant de la quitter.

Sur une étendue relativement restreinte du Texas sudouest, on pourrait trouver une autre difficulté dans la coutume qu'ont certains fermiers de favoriser la croissance du coton errant (volunteer), ou "seppa," dans l'espoir d'obtenir une récolte précoce et peu coûteuse. Comme l'a fait maintes fois remarquer le Département de l'Agriculture, cette coutume est, à n'en pas douter, la pire qu'on puisse imaginer dans les régions infestées par le weevil. La désastreuse expérience de plusieurs comtés dans la partie sud de l'État pendant plusieurs saisons a abondamment démontré la valeur des avertissements donnés à plusieurs reprises. Le coton produit par les plantes errantes est court, recoquillé et indésirable. Avant l'apparition du weevil, la seule raison qu'il y eut de favoriser leur croissance était d'obtenir la première balle. Aujourd'hui, en raison de sa corrélation préjudiciable avec le problème du weevil, tout essai de culture du coton avec des plantes de coton errant doit être absolument déconseillé.

On pourrait objecter que le brûlage des plantes en automne fait disparaître de bons éléments fertilisants et qu'en continuant cette pratique on réduirait sérieusement la fertilité du sol. À cela nous répondons que la coutume générale, actuellement, est de déblayer

les champs en brûlant les plants au printemps. Donc, en fait, le seul inconvénient additionnel résultant pour le sol de la méthode recommandée, réside dans le brûlage d'une grande partie des feuilles et d'une portion des racines. Néanmoins la destruction des plantes ne peut se faire qu'après la chute d'une grande partie des feuilles et, dans d'autres cas, après la défoliation complète des plantes par la chenille du coton. Les éléments fertilisants des diverses parties de la plante du coton ont été soigneusement déterminés.^a Un estimé de la valeur de tous les éléments que la destruction automnale pourrait faire disparaître, estimé basé sur la liste des valeurs commerciales adopté par les stations expérimentales pour 1898, montre que la perte par acre serait minime. Il est clair que le planteur pourrait non seulement compenser cette petite perte, mais encore augmenter grandement la fertilité de la terre par l'emploi d'engrais commerciaux dont le coût serait insignifiant en comparaison du gain produit par le récolte suivante et résultant de la diminution des dommages causés par le boll-weevil. Dans certains cas, naturellement, l'enlèvement de l'humus fourni par les chaumes peut être plus important que l'enlèvement des éléments fertilisants. Ne pas perdre de vue, cependant, que la manière la moins coûteuse et la plus efficace d'ajouter de l'humus au sol réside dans l'emploi du fumier frais, lequel attire de plus en plus l'attention dans toute la région cotonnière.

En fait, les objections qui précèdent ne sont pas nécessairement sérieuses. Elles ont trait aux changements généraux rendus nécessaires, dans la culture du coton, par les ravages du boll-weevil. Comme les planteurs commencent à bien le savoir, il ne sera pas possible aux tenanciers de cultiver autant de terre qu'autrefois. En cultivant une moindre étendue et en donnant plus de soin à ce qui reste, on arrivera à produire plus de coton et ainsi les objections mentionnées disparaîtront en grande partie.

CONCLUSION.

L'auteur de ces lignes, après avoir étudié et éprouvé les méthodes ci-dessus recommandées, ayant pour but de se rendre maître du weevil et après en avoir fait l'expérience, croit fermement que la destruction des chaumes au commencement de l'automne est la méthode la plus efficace que l'on connaisse pour réduire réellement le nombre de ces insectes. Cette destruction ne coûtera qu'une petite fraction de la dépense occasionnée par le cueillage fréquent, au printemps, des feuilles florales (squares) infestées par les weevils qui ont hiberné, et elle est bien supérieure, pour réduire le nombre des weevils, à la coutume de cueillir sur les jeunes plantes les weevils qui ont hiberné. Il est essen-

^a Voir le Bulletin 33 de l'Office des Stations Expérimentales du Département, pp. 81-142.

tiel de détruire de bonne heure les chaumes si l'on veut arriver au plus grand succès dans tout système entrepris pour se rendre maître du weevil. Tous les autres moyens recommandés, quoiqu'excellents pour s'assurer une récolte, sont de la plus grande valeur pourvu qu'on ne manque pas d'employer celui-là, le plus important de tous. Depuis les premières investigations sur le boll-weevil entreprises par ce Département, le Dr. L. O. Howard a reconnu et fait remarquer que cette pratique est de la première importance, et l'expérience de ces dernières années n'a fait qu'ajouter la certitude à cette conviction. Un certain nombre de planteurs l'ont adoptée et leurs travaux, ainsi que ceux faits en grand par le Bureau d'Entomologie, ont abondamment démontré son efficacité. *Il ne faut pas croire que la seule chose à désirer soit d'obtenir une récolte immédiate. La destruction des chaumes faite de bonne heure et complètement, voilà sans aucun doute le plus important élément, considéré séparément, pour assurer le succès pour l'année suivante.*

Une action concertée dans la destruction automnale est, cela va sans dire, désirable; et les meilleurs résultats ne seront obtenus que lorsque des communautés entières auront adopté cette méthode. Mais aucun planteur ne devrait hésiter à cause de l'indifférence des voisins. Le fait que les weevils changent peu de place jusqu'au jour où l'ensemble de la récolte est assuré, aidera grandement à sauver un champ, alors même que d'autres tout proches n'auraient pas été proprement traités, et, dans ce cas même, le succès de la méthode dans un champ sera un puissant aiguillon pour son adoption générale à la saison suivante.

Il est vrai que les recommandations contenues dans cette circulaire entraînent un changement considérable dans la culture du coton. Néanmoins les changements importants causés jusqu'à ce jour par l'emploi de graine et d'engrais perfectionnés ont amené, eux aussi, des bouleversements. Le département espère que les agences qui donnent leur concours dans cette question—c'est-à-dire les associations d'hommes d'affaires—déploieront partout la même énergie à favoriser l'exécution de ce qui est, après tout, la plus importante mesure destinée à maintenir la suprématie du coton sur le territoire du weevil.

Approuvé:

JAMES WILSON,

Secrétaire de l'Agriculture.

WASHINGTON, D. C., 3 septembre 1908.

[Cir. 95]

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United States Department of Agriculture,
BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

THE CATALPA SPHINX.

(*Ceratonia catalpa* Bdv.)

By L. O. HOWARD and F. H. CHITTENDEN.

INTRODUCTORY.

Our native species of catalpa, the eastern catalpa (*Catalpa bignonioides*) and the hardy or western species (*Catalpa speciosa*), are comparatively free from insect attack. Such common shade-tree defoliators as the bagworm and fall webworm occasionally feed upon the leaves, but apparently do so only in the absence of food more palatable to them. There is one insect, however, the catalpa sphinx (*Ceratonia catalpa* Bdv.^a), which lives normally and exclusively on the foliage of this tree and in some seasons does very considerable injury, frequently causing complete defoliation. There is evidence that this species, owing doubtless to the increased planting of these trees in regions other than their native homes, has also increased its natural range, and injury is more extensive now than formerly. During the year 1906 injury was noticed in Ohio, New Jersey, and Pennsylvania, but in 1907 reports of damage which reached this office indicated general infestation over a much larger area. This included portions of Maryland, Virginia, the District of Columbia, Ohio, New Jersey, Indiana, and Florida. Mr. A. S. Peck, of the Forest Service, also reports injury in July, 1907, at Warsaw, Ky. It is probable that the insect also infested the intervening territory not yet reported to this Bureau.

DESCRIPTIVE.

The catalpa sphinx in its active feeding stage is a large caterpillar, attaining a length of fully 3 inches. It is very variable in color, there being a light and a dark form, as in the case of some related species. The prevailing colors are yellow and black, and this, com-

^a Synonyms are *Sphinx catalpa* and *Daremma catalpa*.

bined with the large size of the insect, makes it a conspicuous object on infested trees. The complete life history by stages or periods of growth is well illustrated by the accompanying figure ^a on page 3, the drawing for which was made by the late Dr. George Marx, of whose excellent and artistic work it is one of the best published examples.

The parent of this caterpillar is a large grayish-brown moth of the family Sphingidæ, marked as shown in figure 1, *k*. It has a large heavy body and powerful wings with a total expanse of 3 inches. It deposits its eggs in masses, and in this respect differs from other sphingids. An egg mass is shown in the illustration at *a* and an individual egg at *l*. The young caterpillars are paler than the mature ones, being pale yellow and having a stout black anal horn. Two striking variations of the larva in the later stages are shown at *f* and *e*, while *h* represents the commonest dark form of caterpillar.

ORIGINAL HOME AND PRESENT DISTRIBUTION.

This insect is a strictly North American species, and its range is given by Dr. J. B. Smith ^b as from "Virginia to Florida; westward to the Mississippi; as far north as Indiana." It is an especially common form in Virginia, Maryland, and Ohio, and of late years has extended its range northward on the Atlantic coast, since it has been received at this office from several localities in southeastern Pennsylvania and New Jersey.

In 1888 it was recorded from Delaware County, Pa., and Mr. Frank M. Jones ^c states that he received it in 1893 from Sussex County, Del., while in 1894 a specimen was taken at electric light at Wilmington, Del. In 1898 the larvæ appeared on the catalpa trees at Wilmington in great numbers. The species has spread northward in Delaware, and it has greatly increased in numbers where it was formerly very rare. Its northward range seems so far to be limited by Illinois in the West, in which State Professor Forbes recorded it in 1884. ^d The range of its food plant is as follows: From the Gulf of Mexico in western Florida and on the rivers in Alabama and Georgia westward and northward along the Mississippi and its southern tributaries in the great delta formation to above the mouth of the Ohio; thence up the Wabash and White rivers of Indiana to near Vincennes. ^e This has been taken by Riley to indicate also the range of the catalpa sphinx. Published records, however, were lacking until recently to

^a Originally published as Plate XIII, Report of U. S. Dept. Agr. for 1881-82.

^b Monograph of the Sphingidæ of America North of Mexico, p. 205, 1888.

^c Entomological News, November, 1898, p. 262; Feb., 1899, p. 43.

^d Trans. Ill. State Hort. Soc., 1884, p. 125.

^e For particulars regarding the present range, see Circ. 82, Forest Service.

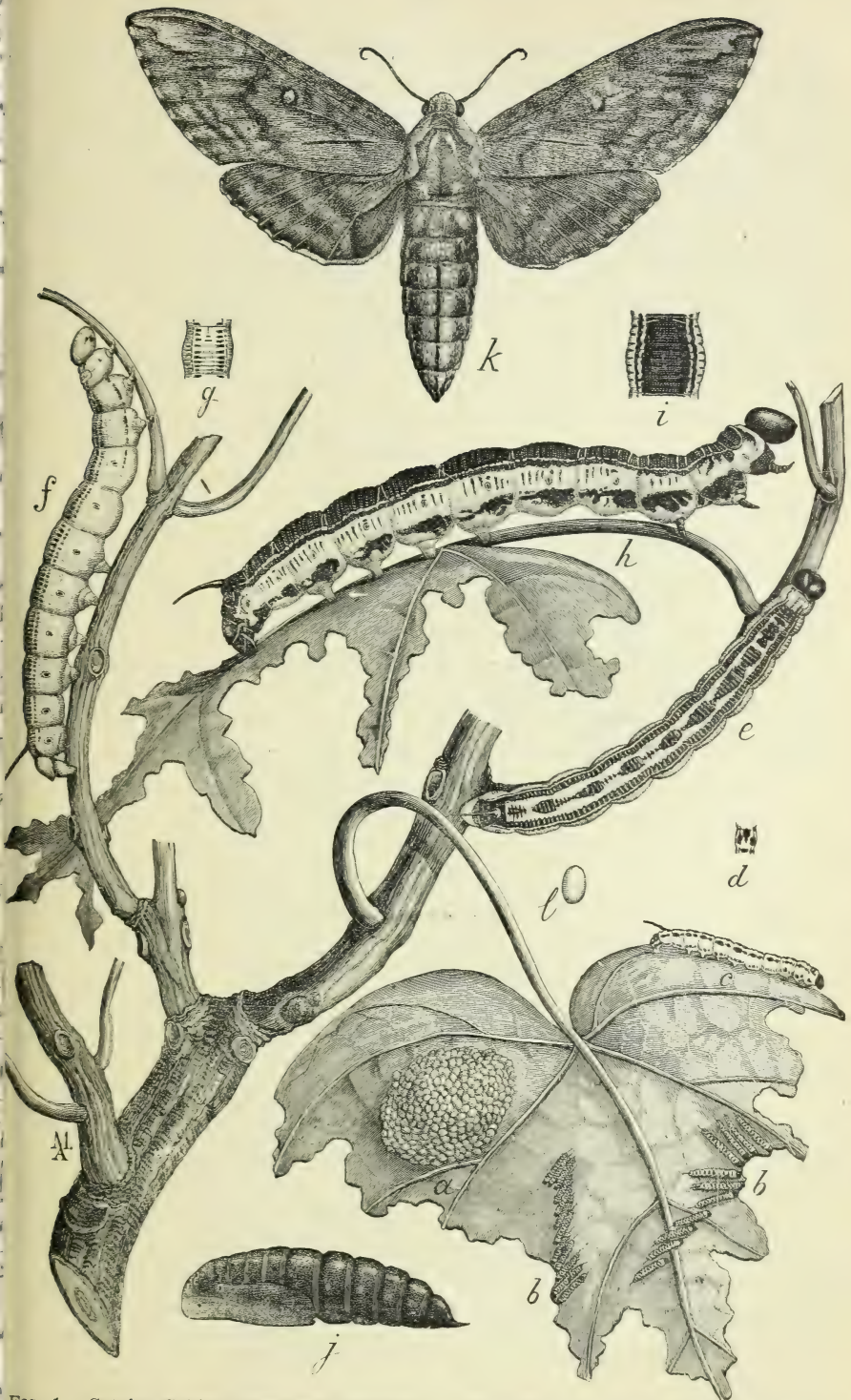


FIG. 1.—*Catalpa Sphinx* (*Ceratonia catalpæ*): a, egg mass; b, b, newly hatched larvæ; c, larva one-third grown; d, dorsal view of joint of c; e, f, two differently marked, nearly full-grown larvæ; g, dorsal view of joint of f; h, full-grown dark larva; i, dorsal view of joint of same; j, pupa; k, moth; l, egg, enlarged. All natural size, except l (Marx del.).

show its general occurrence west of Florida and Georgia along the Gulf. From the files of the Bureau of Entomology we learn that this species was observed in Alabama in 1883, and was received from Denison, Tex., in 1889. More recently the species has been reported from Arkansas (by Webster, in 1900) and from Cedar Creek, Ala. (in 1904), following which it occurred at St. Elmo, Ala. In 1899 the species was not known to occur in New Jersey, but in 1900 it was observed in Camden County, near Philadelphia, and in Hunterdon County.^a By 1906 it had become established at Elberon and Bloomfield, the latter—westward and a little north of Manhattan, New York City—being the northernmost point of which we have knowledge of its occurrence in the East.

LIFE HISTORY AND HABITS.

The catalpa sphinx is subject to considerable fluctuations in numbers. For one or two years or even several years it will not be noticed in a given locality and will then suddenly appear in great masses, completely defoliating the trees and covering the ground beneath them with its larval excrement. It is interesting to observe that John Abbot, who collected the type specimens in Georgia, mentioned more than a hundred years ago the fact that the fishermen who inhabited the borders of the swamps hunted for these larvæ as the best bait for catching fish, and it is said that this bait is so esteemed for this purpose in some parts of Florida that the catalpa is often cultivated for no other purpose than to attract the insect.

The eggs, as has been stated, are laid in masses, and the young larvæ feed gregariously for some time. The prolificacy of the species may be judged from the fact that an egg mass in the collection of the U. S. National Museum contains nearly 1,000 eggs. The mass is not compact and is slightly fastened to the underside of the leaves. Sometimes, according to Koebele, the eggs are laid in smaller masses on the stems and branches. The larvæ molt four times, becoming as they grow older very variable in their markings. In the extreme South the insect is reported to be found in all stages during the summer, and there are three or four generations annually, the last hibernating in the pupa state beneath the ground and giving forth the moth the following March. In the summer time, according to Koebele, whose observations were made in Florida, the time occupied by an entire generation is about six weeks. In the vicinity of Washington, at Coalburg, W. Va., and probably everywhere in its northern range, there are two generations, or broods, annually.

^a Entomological News, November, 1900, pp. 608, 611.

NATURAL ENEMIES.

A number of parasitic insects attack and kill the catalpa sphinx. *Apanteles congregatus* Say, a common, widespread, and very generally parasitic enemy of sphinx caterpillars, attacks this species quite as freely as it does the "horn worms" of tobacco and tomato. Unfortunately this parasite is in turn parasitized by other Hymenoptera, of which two species, *Mesochorus aprilius* Ashm. and *Hemiteles mesochoridis* Riley MS., are recorded. These secondary parasites in our experience, however, are not generally abundant; hence the beneficial primary parasite flourishes in spite of their attack. *Apanteles congregatus*, the primary parasite, is a minute, four-winged, wasplike fly. Its larva, a white, maggotlike creature, develops within the body of the caterpillar, and when full fed and ready for transformation each individual eats a hole through the skin of the caterpillar and spins its little white cocoon on the outside. Two hundred or more of such cocoons may be seen on the body of a single caterpillar. After a few days the winged parasite issues from the cocoons to lay eggs and produce another generation of larvæ. This parasite is abundant throughout the eastern United States.

Microplitis (*Apanteles*) *catalpa* Riley, which appears to be a special parasite of the genus *Ceratomia*, is also recorded as an enemy of the species under discussion. Extensive parasitism of the catalpa sphinx by this species was observed by Mr. A. F. Burgess at Jackson, Ohio, in 1905. In one case a large number of the hyperparasite *Hypopteromalus tabacum* Fitch and a few individuals of *Horismenus* (*Holcopelte*) *microgastri* Ashm. were reared from the same lot of larvæ, the hyperparasites outnumbering the primary parasites four to one. This, however, is exceptional.

Two common species of tachina flies, *Euphorocera claripennis* Macq. (fig. 2) and *Frontina frenchii* Will., also attack the larva of the catalpa sphinx. These are general parasites of Lepidoptera, the former infesting 27 distinct species, the latter 22.

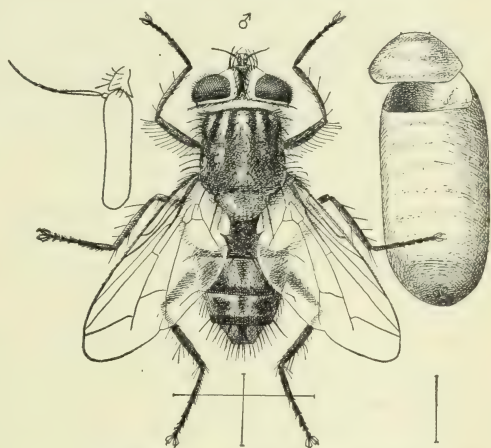


FIG. 2.—*Euphorocera claripennis*, a parasite of the catalpa sphinx: Adult with puparium at right and enlarged antenna at left. (From Howard.)

A few birds prey upon the caterpillar, but most of them evidently find it, when full grown, a rather tough morsel, the skin being especially tough and thick and the insect a very muscular one, so that, in fact, it is difficult to crush one with the end of a cane. Among the birds which have been recorded as destroying this insect are cuckoos, the catbird, and the Baltimore oriole.

REMEDIES.

The catalpa sphinx may be readily destroyed by different methods.

Hand picking.—Owing to its large size, the caterpillar is easily seen, and it is possible to control it by hand picking with the aid of a long ladder and a 12-foot pole pruner or similar device.

Arsenicals.—The insect can be destroyed by an arsenical spray of either Paris green or arsenate of lead, applied as for other shade-tree pests, such as the tussock moth and fall webworm.^a We may take advantage of our knowledge of the gregarious habit of the young of this caterpillar by watching rather closely for it in the spring, and if the leaves are observed to be eaten in any particular place, a poisonous spray should be applied. This may frequently save an entire tree. Where only a few trees are to be treated, it will be best to spray all the leaves. Owing to the fact that the foliage is frequently infected by a leaf-spot disease,^b the added precaution of using Bordeaux mixture as a diluent for either the Paris green or arsenate of lead is advisable.

Destruction of the pupæ.—Where the caterpillars have been so abundant as to have affected the trees, it will pay as a precaution for the following year to spade up the ground thoroughly and disintegrate it in the fall so as to destroy the pupæ, which will be found concentrated under the surface of the ground in the immediate vicinity of the trunk.

Protecting the parasites.—The second or last generation, which appears in September and October, is largely destroyed by parasites which are frequently very abundant just as the oldest caterpillars are beginning to reach full growth. At this time the parasites, which have been previously mentioned, issue from the body of their host and spin large masses of white cocoons on the backs of the caterpillars. These masses are so large that they can be seen at a considerable distance against the black stripes of the host insect. It is not advisable to destroy the caterpillars at this stage, as the parasites are very beneficial and in ordinary seasons will reduce the numbers

^a For directions, see Farmers' Bulletins 99 and 127, which may be obtained gratis upon application.

^b *Phyllosticta catalpa*.

of the sphinx caterpillars so that they will not appear the following season to do much harm. Where the caterpillars can be easily gathered, it will pay to pick them from the leaves and transfer them to barrels or large boxes covered with wire netting. This will prevent the caterpillars from issuing or falling a prey to birds or other animals, and will insure the issuance of the parasites through the meshes, thus encouraging their good work. A few holes should be bored in the bottom of the barrels or boxes used, small enough to prevent the caterpillars from crawling through them into the ground. This will prevent the accumulation of water after rains which might drown the insects or set up putrefaction in the mass.

If the cooperation of neighbors who have catalpa trees growing on their premises can be secured, this caterpillar can be largely controlled for several years in succession.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *November 6, 1907.*

[Cir. 96]

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE BAGWORM.

(*Thyridopteryx ephemeraformis* Haw.).

By L. O. HOWARD and F. H. CHITTENDEN.

GENERAL APPEARANCE AND NATURE OF ATTACK.

Shade trees, shrubs, and hedges, and in particular evergreens, are much subject to injury by a medium-sized caterpillar which has a curious habit of crawling about on the infested trees in a bag-like case, whence its common name of bagworm or basket worm. In the shelter of these cases the insects undergo all their transformations, after which the bags remain attached to the plants for some time and are conspicuous objects on leafless trees and shrubs in late autumn and in winter. Like the tussock moth^a and the fall webworm^b this species is preeminently a pest on the streets and in parks and private grounds of cities and towns and is even more subject to fluctuation in numbers. It is, however, more limited in distribution and not found as a rule north of southern New York and the central portions of Pennsylvania and Ohio. South of these points it is in certain years very troublesome and the subject of much complaint. Such a year was 1907, when the bagworm attracted greater attention than any other tree defoliator. Numerous complaints were received of injuries in the region mentioned, and especially from the States of New Jersey, Pennsylvania, Maryland, Virginia, West Virginia, Ohio, Indiana, and Illinois. The natural enemies of this insect (see p. 6) were comparatively scarce, and there is a strong possibility of a recurrence of injuries in the years to come.



FIG. 1.—Bagworm
(*Thyridopteryx
ephemeraformis*).
Natural size (after
Riley).

The general appearance of the bagworm is shown in figure 1, which illustrates the caterpillar when nearly full grown, in its characteristic bag. When removed from its bag it looks as shown in figure 2, *a*, which represents the larva at maturity. At this period in its develop-

^a *Hemerocampa leucostigma* S. & A.

^b *Hyphantria cunea* Dru.

ment it may attain a length of about three-fourths of an inch. The body is soft in texture and dull brownish or blackish, while the head and thoracic segments are horny and whitish, mottled with dark brown.

ORIGINAL HOME AND PRESENT DISTRIBUTION.

The bagworm is unquestionably native to North America. It abounds in the Southern States, and its proper home—that is to say, the part of the country where it reaches its maximum—is in the Lower Austral life zone. It extends through a considerable portion of the Upper Austral zone, but there are indications that it has gradually spread into this territory from more southern regions.^a The shade trees of Baltimore, Washington, St. Louis, and other more southern cities are frequently defoliated by this insect. Northward it occurs

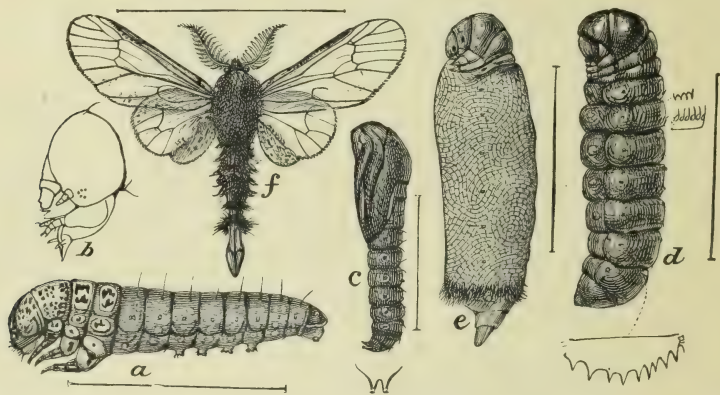


FIG. 2.—Bagworm (*Thyridopteryx ephemeraeformis*): a, Full-grown larva; b, head of same; c, male pupa; d, female pupa; e, adult female; f, adult male. All enlarged (from Howard).

through New Jersey and at many points in Pennsylvania, including the cities of Harrisburg, Ellittsburg, Allentown, and Swarthmore. Farther west it has been found at Columbus, Marietta, South Salem, and other localities in Ohio, at several points in West Virginia, at Brooklyn, Ind., in Pecatonica, Thompsonville, and Allendale, Ill., and so on west to Oklahoma. Everywhere south of these localities, except in the immediate Gulf region, it abounds. In the East it is commonly found in New York City and Brooklyn, and at several points on Long Island. In the Hudson River Valley region it has been recorded by Felt at Yonkers and Mount Vernon, and has been collected at New

^aIn the main the bagworm is one of those characteristic forms like the wheel-bug (*Arilus cristatus* L.), the Carolina mantis (*Stagnomantis carolina* L.), and the larger digger wasp (*Sphecius speciosus* Dru.), true southern forms which are gradually extending their northward range by following the seacoast or valleys, or, if carried accidentally northward upon railroad trains, establishing themselves at points beyond their former habitat.



FIG. 3.—Arborvitæ infested by bagworms. (Original.)

Haven, Conn., but it is not known to be injurious in these localities. It has been sent to the Bureau of Entomology from Springfield, Mass., but probably does not breed there.

FOOD PLANTS.

The bagworm, although a very general feeder, displays a particular fondness for evergreens of all kinds and especially for arborvitæ, hence it seems probable that one or the other of these was its original or normal food plant (fig. 3). The species becomes exceedingly abundant every few years, and at such times it may be found on shade, orchard, and forest trees of nearly all kinds. It is fond of the maples, particularly the cut-leaved and silver maples, and the related box elder; also of the poplars and mulberry, less so of the elms, and apparently still less so of the oaks. It feeds more or less freely, however, on most other trees and shrubs, and even on many low-growing semi-woody plants, such as elder, mallows (*Hibiscus*), and ragweed (*Ambrosia trifida*). Thus, in the absence of its choice food plants, it is able to subsist on the foliage of almost any of the plants of the character enumerated and which may be available, but it does not seem to live on grasses and herbaceous plants generally.

HABITS AND LIFE HISTORY.

The bagworm overwinters in the egg stage within the old female bags, and for this reason hand-picking in winter time is an efficacious remedy. In the late spring the young hatch from the eggs, crawl out upon the twigs, make their way to the nearest leaf, and immediately begin to feed and to construct cases or bags for themselves. They spin a large amount of silk and attach to it, for additional strength and protection, bits of leaf or of twig, evidently attempting to disguise the nature of the case as well as to strengthen it. The larva is remarkably soft-bodied, except for its head and strong thoracic plates, and it is necessary that the soft abdomen should have some protection. The construction of the bag of an allied species was carefully studied by H. G. Hubbard, and it is a very interesting performance.

The young larva (fig. 4, *a*) cuts off with its jaws a small fragment of leaf which it places between its front legs, gradually forming a pile fastened loosely with silk. When the pile becomes a transverse tangle about as long as the body it is fastened at each end loosely to the surface upon which it rests; then the caterpillar, after placing itself at right angles, dives under the mass, turning a complete somersault, so that it lies on its back, bound down by the fillet. It then twists around and stands upon its feet, having its neck under a sort of yoke (fig. 4, *b*). It makes the yoke into a complete collar, adding bits to each end until

the circle is complete. Then row after row of fragments is added until the case becomes a hollow cylinder (fig. 4, *c*). One end is then closed up and the inside lined with a tough coating of silk, the case being then extended upright and fastened at one end. When it is fully completed the larva crawls away, with the case carried upright like a cap on the upturned end of its body. In the illustration *d* shows a completed bag made by the young larva, tightly appressed to the flat surface, the larva being concealed within. Such bags may frequently be found on leaves, and are quite puzzling to the uninitiated until the larva pokes out its head and slowly walks off. As the caterpillar grows the case is constantly enlarged, bits of twigs and any other small objects being used to ornament the outside, and these objects will vary with the kind of tree upon which the caterpillar is feeding. While the larva is small it carries its case erect, but when it is larger the case hangs down (fig. 1). The larval skin is cast four times, and during the molting the mouth of the bag is kept closed with silk. There is a small opening in the extremity of the bag through which excrement and cast skins are pushed. The male bags are smaller than those of the females, reaching a length of about an inch, while those of the females are much larger. Toward the end of August, about Washington, D. C., the larva completes its growth, attaches its bag firmly by a silken band to a twig, strengthens it inside with an additional layer of silk, and within this retreat, which now becomes its cocoon, transforms to pupa with its head downward. The pupal period lasts about three weeks, and then the imago emerges. The male chrysalis works its way out of the lower opening, and the winged moth issues

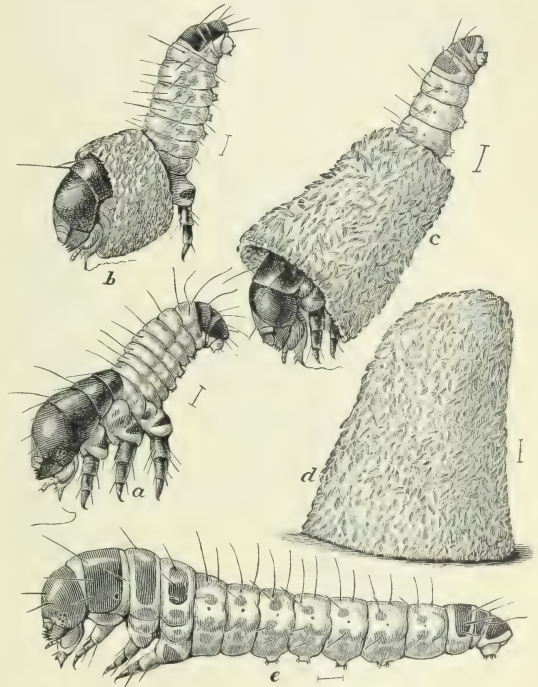


FIG. 4.—*a*, Newly hatched bagworm before making its case; *b*, same just beginning case; *c*, showing case nearly completed; *d*, completed case, insect concealed within; *e*, larva after first molt. Highly magnified (original).

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through the cracking skin, leaving the chrysalis hanging from the bag, as shown at *c*, figure 5. The chrysalis of the female does not push its way at all out of the bag, but the skin cracks and the female gradually works her way partly out, her head reaching the lower end of the bag, (fig. 5, *d*). The males fly about, seeking the bags of the females, and when one is found in which the head of the female is near the end, showing that she has emerged from her chrysalis skin, the male pushes his enormously protrusive and, in fact, telescopic genital apparatus up into the bag to the anal end of the female and fertilizes her. The female then works her way back into the chrysalis skin, gradually filling it with eggs until more than half of it is filled, scattering in among the eggs some of the sparse hairs from her body. Having done this she

forces her shriveled body out of the opening, falls to the ground, and dies. The eggs remain in this way until the following spring, when they hatch, as previously described.

There is thus only one generation annually.

NOTE.—There is a possibility that the bags of this extremely common insect might be made commercially useful. Its silk, from a practical standpoint, has always been ignored, but it is firmer and stronger and more easily spun as carded silk than that of most other native silk cocoons.

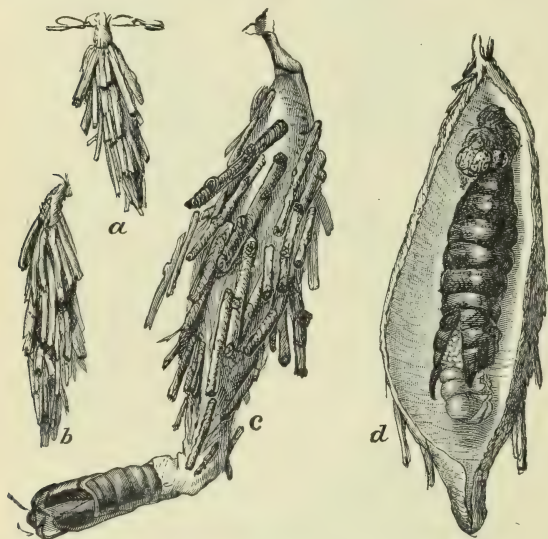


FIG. 5.—Bagworm at (*a*, *b*, *c*) successive stages of growth. *c*, Male bag; *d*, female bag. Natural size (from Howard).

NATURAL ENEMIES.

Although apparently well protected from the attacks of birds by its tough case, the bagworm is somewhat extensively parasitized by several forms of ichneumon and chalcis flies, most of them species which affect also similar tree-feeding caterpillars. Prominent among these is the common *Pimpla inquisitor* Say (fig. 6), which, however, more commonly parasitizes the tussock moth and tent caterpillars.^a The related *P. conquisitor* Say is also a parasite of the bagworm and a third species of ichneumon, *Allocota (Hemiteles) thyridopterigis* Riley (fig. 7), is usually the most abundant of all. Four or five individuals of this species commonly infest a single bagworm, spinning for themselves white silken cocoons within the bag.

^a *Malacosoma* spp.

The species last mentioned was for many years credited with being a primary parasite of the bagworm, although recent observations would indicate that it is a secondary parasite when infesting other

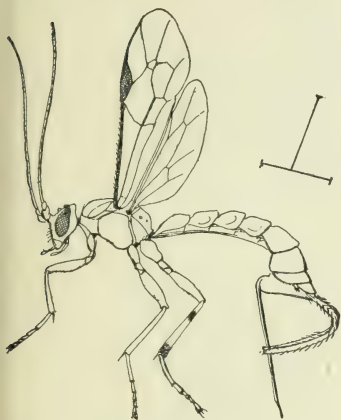


FIG. 6.—*Pimpla inquisitor*: Female, from side. Enlarged (from Howard).



FIG. 7.—*Allocota (Hemiteles) thyridopterigis*. Much enlarged (original).

caterpillars. This might be explained by the hypothesis that this parasite oviposits only in cocoons or cases of firm texture, and therefore can not be the primary parasite of an insect which is not provided with a case of that character.



FIG. 8.—*Spilochalcis marix*. Much enlarged (after Riley).



FIG. 9.—*Chalcis ovata*: Adult. Enlarged (from Howard).

Certain chalcis flies also breed in the bags of this insect. These include *Spilochalcis marix* Riley (fig. 8), *Chalcis ovata* Say (fig. 9), and the common little *Dibrachys boucheanus* Ratz. (fig. 10). This last is a hyperparasite, in the case of the bagworm probably secondary, and in the case of other caterpillars a

tertiary parasite. *Habrocytus thyridopterigis* Ashm. (fig. 11) is assumed to be a tertiary parasite on *Allocota thyridopterigis* Riley, when the latter is a secondary parasite of the tussock moth, but may be secondary when breeding in the cases of the bagworm.

REMEDIES.

When the bagworm occurs upon deciduous trees it can be controlled by hand-picking the bags in the winter, but when it affects evergreen trees it is practically impossible to apply this remedy with profit unless the plants are badly defoliated. Therefore for the treatment of evergreens spraying is a necessity.

The methods of controlling shade-tree pests in cities and towns, as outlined in Farmers'

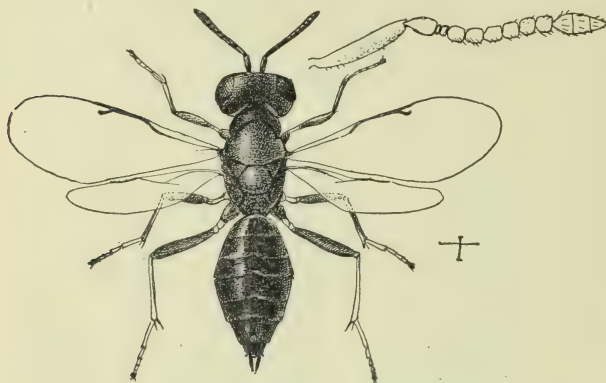


FIG. 10.—*Dibrachys boucheanus*: Adult female and antenna of male. Much enlarged (from Howard).

Bulletin No. 99,^a on pages 25–29, are in part applicable to this species. This bulletin should be read by persons who have experienced trouble from the depredations of the bagworm.

Collecting the bags.—

One of the most important remedies consists in gathering the bags with the contained insect by hand and either burning them or preserving them to liberate the useful parasites which have been previously mentioned. This work may be facilitated by the use of a 12-foot pole pruner or similar

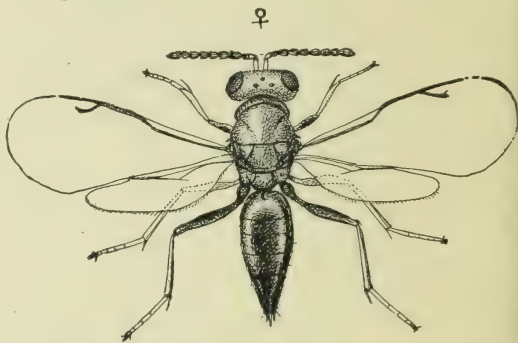


FIG. 11.—*Habrocytus thyridopterigis*. Greatly enlarged (from Howard).

appliance, and can be intrusted to those ordinarily unemployed, such as children and aged persons. Where the trees are very tall it will be necessary to use a long ladder. For best results the cooperation of neighbors who are troubled with the same pest should be secured.

^a This publication may be had gratis on application to the Department of Agriculture.

Very considerable immunity from future injury will result by care in the employment of this method. It is particularly useful where only a few trees are infested. The bags are such conspicuous objects on defoliated or bare trees in winter that it is not at all difficult to detect them, but in cases where comparatively few insects are present on evergreen trees they are not so easily seen.

Encouraging the parasites.—When many trees are infested it is advisable to keep the hand-picked bags for a considerable time in receptacles, such as barrels covered with netting, preferably of wire, so that the numerous beneficial parasites of the pest will be able to issue in the spring and assist in the control of the bagworm the following year. One or two holes bored in the bottom of the barrel or box will prevent water from accumulating and drowning the insects. Where the bags can be placed in piles in an open space or inclosure distant from trees and free from disturbance, the young insects, having very limited powers of locomotion, will soon perish of starvation, as they will not be able to reach the trees or shrubs after they hatch.

Spraying with arsenicals.—On evergreen, where the bags are more or less difficult to find, hand-picking can not be advised. A striking instance of the futility of this method under such circumstances was given by Prof. C. V. Riley in his testimony at a conference on the gipsy moth in 1891. He said that he once tried to protect a cedar tree not more than 6 feet high, upon his own grounds at Washington, by hand-picking. He worked for two consecutive months picking off small bags from that tree, the progeny of not more than two females. Almost daily he went to the tree and found fresh specimens which he had overlooked the day before. For evergreen trees, therefore, an arsenical spray is the best remedy. In connection with the story of his experience just related, Professor Riley stated that he had absolutely stopped injury by the bagworm on large trees in the Smithsonian grounds by spraying, and in the summer of 1895 we had a similar experience on the grounds of the Agricultural Department at Washington. Trees sprayed with Paris green at the rate of 1 pound to 150 gallons of water were completely rid of larvæ of the bagworms. It is easier to reach the bagworms on evergreen than on large-leaved deciduous shade trees, such as maple and elm, but if carefully carried out spraying will result in the destruction of the bagworms, so that the collection of the bags in winter will not be necessary. Arsenate of lead at the rate of 1 pound of the prepared paste form to from 25 to 50 gallons of water will be found even more useful than the Paris green, as its greater adhesiveness renders it less likely to be washed off by rains, which in some seasons frequently occur almost daily at the time when the larvæ are beginning to work.

The best time to apply the arsenical is when the eggs hatch, or shortly afterwards, and the best methods of spraying shade trees are discussed in Farmers' Bulletin No. 99.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *December 2, 1907.*

[Cir. 97]

O

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE APPLE-TREE TENT CATERPILLAR.

(*Malacosoma americana* Fab.)

By A. L. QUAINANCE,

In Charge of Deciduous Fruit Insect Investigations.

The conspicuous, unsightly nests or tents of this insect (fig. 2) are familiar objects in the spring in trees along roadways, streams, fences, in neglected orchards, and elsewhere. The gregarious caterpillars construct the tents for their protection, and these, at first small, are gradually enlarged as the larvæ grow, often to a foot or more in height and diameter, the size varying with the number

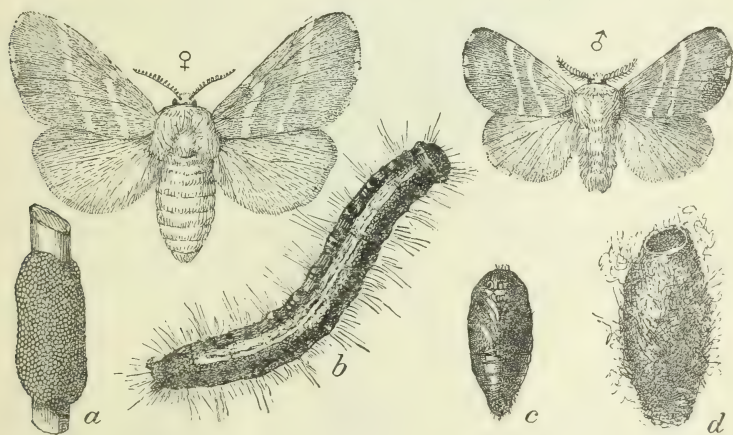


FIG. 1.—Stages of the apple-tree tent caterpillar: a, Egg mass; b, larva; c, pupa; d, cocoon; ♀, female moth; ♂, male moth. About natural size (original).

of individuals in the colony. The caterpillars feed upon the foliage of the trees, stripping the leaves from the limbs adjacent to the nest, and if there be several colonies in a tree, as is frequently the case during periods of abundance, the foliage may be quite destroyed, leaving the branches as bare as in midwinter.

DISTRIBUTION AND FOOD PLANTS.

The tent caterpillar is a native American species occurring quite generally in the United States from Canada south to Florida and westward about to the Rocky Mountains. From the Rockies to the Sierras, according to Dyar, the species is replaced by *Malacosoma fragilis* Stretch, which ranges from Canada to Mexico, and this latter form in the Pacific Northwest is replaced by *Malacosoma pluvialis* Dyar.

The tent caterpillar has been a troublesome pest from the earliest times. As stated by Fitch, its injuries in Massachusetts in the years 1646 and 1649 led the early settlers to term these "caterpillar years." At rather long and irregular intervals the caterpillars have been excessively abundant in different parts of their range, but more particularly in the New England States. This species was among the first to receive attention by the early American entomologists, and the principal features in its life and habits have been known for many years. Throughout its extended distribution the insect is likely to be abundant each year in one or more localities and often over a considerable territory. Scattered nests are to be found usually during any spring, though during some seasons these are but little in evidence.

The favorite food of the tent caterpillar is the wild cherry, and this is probably its native food plant. Next to the wild cherry the apple is apparently preferred. In the absence of its favorite food, or under special conditions, it attacks many other plants, as plum, peach, thorn, pear, rose, and other members of this group; also beech, witch-hazel, elm, maple, various species of willows, oaks, and poplars, etc. During periods of unusual abundance trees are more or less completely defoliated, and at a time when they most need the leaves for their growth or for the development of the fruit, and they are materially weakened, though rarely killed.

DESCRIPTION AND LIFE HISTORY.

The egg.—Eggs are deposited in masses or belts encircling the smaller twigs, as shown in fig. 2, and at *a*, fig. 1. Different egg masses may vary from one-half to three-fourths of an inch in length and contain from 150 to 250 eggs. The average number of eggs in several egg masses counted by Prof. V. H. Lowe on peach and apple was about 223 each. Each egg belt is deposited by an individual female and ordinarily represents the entire number which she will deposit. Eggs are placed on end, cemented closely together, the whole oval-shaped mass being finally covered with a layer of light-brown frothy glue, which soon becomes tough, brittle, and glistening.

Eggs are deposited by the moths by early midsummer, or earlier in the South, the embryonic larvæ developing so that by fall they are practically full grown, although remaining within the egg until the

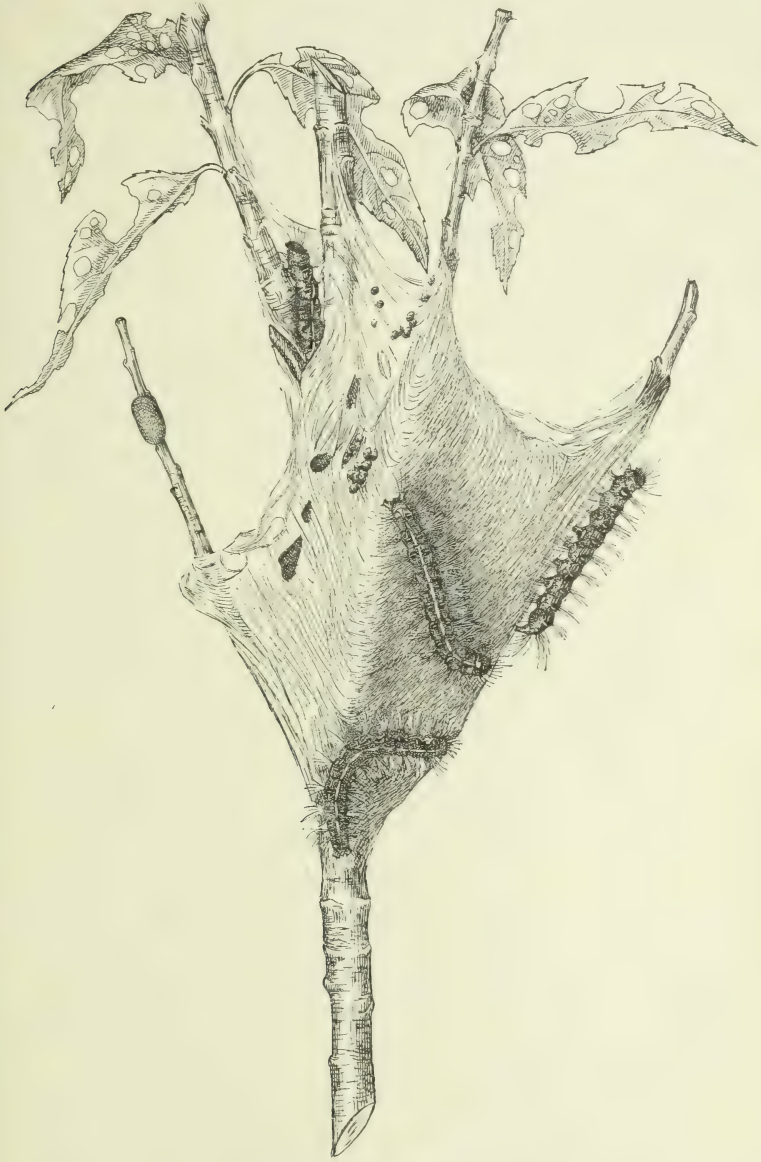


FIG. 2.—Apple-tree tent caterpillars (*Malacosoma americana*) and "nest;" egg mass or belt on small twig at left. "Nest" considerably reduced; caterpillars one-half natural size. (Original.)

following spring. With the coming of a warm spell the larvæ escape by gnawing through their egg shells, often before there is

foliage out for food, and under these circumstances they may feed upon the glutinous covering of the egg mass.

The larva.—In the presence of food the larvæ begin the formation of their nest in about two days from hatching, usually selecting the crotch formed by two limbs and ordinarily one that is not far from the egg mass. The caterpillars are sociable, those from one egg mass inhabiting one nest and feeding together upon the adjacent leaves. If two egg masses happen to be deposited close together, as on the same or adjacent twigs, the resulting caterpillars may unite in one nest. Wherever they go each larva spins a thread of silk, the young individuals hanging suspended from a silken thread when they drop, as do the cankerworms and many other larvæ. The nests, at first small and affording but little shelter, are gradually enlarged as the caterpillars grow and soon furnish ample protection. Upon close examination the nests of this species will be found to be made up of layers of silk, with room for the larvæ between the layers. According to Fitch these layers are the result of the caterpillars' habit of lying on the outside of the nest during bright weather, the few restless individuals crawling back and forth over the resting mass, spinning silk as they go, soon forming a new layer. During rainy and cloudy weather the larvæ remain mostly within the nest, but when the weather is favorable they feed at regular intervals; according to Fitch, in the morning, in the afternoon, and again during the night. Upon becoming nearly full grown the larvæ wander singly away from the nest, feeding upon such plants as come to hand. This wandering habit preparatory to pupation results in the scattering of the pupæ and greatly increases the chances of their escape from destruction from their numerous natural enemies.

When full grown the caterpillars are about 2 inches long, cylindrical, deep black in color, with a white stripe along the back and lateral markings, as shown in fig. 1, *b*. On each side is a row of oval pale-blue spots, one on the middle of each segment, and on the anterior side of each is a broader, deep velvety-black spot. The body is sparsely clothed with fine soft yellowish hairs of varying length, thickest perhaps toward the anterior end, where they project forward over the black-colored head. In about six weeks from hatching the larvæ become full grown and wander away from the nest, as stated, in search of suitable places for pupation.

The cocoon.—The larvæ select for pupation any convenient, more or less secluded place, as under loose bark, in grass or brush under trees, along fences, etc. If close to outbuildings the larvæ often make their cocoons in the angles along the sides, in window casings, etc. The cocoon, shown at *d*, fig. 1, is oval in shape, about 1 inch long, and composed exteriorly of coarse, loose, whitish threads of silk

surrounding the tougher parchment-like lining. The silk of the cocoon is intermixed with a yellow powdery substance which readily comes off when disturbed. Cocoons are made more or less singly, though in suitable shelter near the nest several may be found spun together, the larvæ taking advantage of the same protection. Cocoons are frequently found within the nest, though these will usually prove to be parasitized.

The pupa.—Within the cocoon the larva changes to a short, oval, brownish pupa, as shown at *c*, fig. 1. This stage lasts about three weeks, the time varying somewhat; then the moth appears.

The adult.—Both sexes of the tent caterpillar moth are shown in fig. 1, the female to the left. These are dull reddish-brown, stout-bodied moths, with a wing expanse in the females of about 1.5 to 2 inches, and in the males of from 1.2 to 1.3 inches. Obliquely across the forewings of each sex are two nearly parallel whitish lines, as shown in the illustration. Soon after emergence the sexes mate, and eggs are deposited on limbs and twigs. There is but one generation each year, the insects existing in the egg stage throughout the remaining summer and fall and through the winter, the young larvæ coming from the eggs in early spring and forming their nests, or tents, as stated.

NATURAL ENEMIES.

This species is subject to attack by numerous parasitic and predaceous enemies, which undoubtedly exert an important influence in keeping it reduced. Very minute, four-winged flies of the order Hymenoptera deposit their eggs within those of the tent caterpillar moth, the resulting larvæ or grubs finding sufficient food for their growth and development to parent flies. Four egg parasites have been recorded for this species, namely, *Telenomus clisiocampæ* Riley, *Pteromalus* sp., *Platygaster* sp., and *Ablerus clisiocampæ* Ashm., the latter record, however, being undoubtedly incorrect, since this species is parasitic upon scale insects.

Larvæ and pupæ furnish food for a large number of parasites and hyperparasites. Thus W. F. Fiske^a records a total of some 24 species of insects which directly or indirectly feed upon the tent caterpillar. Primary parasites which have been recorded from the larva and pupa are: *Pimpla conquisitor* Say (see figs. 3 and 4), *P. inquisitor* Say, *P. pedalis* Cress., *P. annulipes* Brullé, *Apanteles congregatus* var. *rufocoxalis* Riley, *A. clisiocampæ* Ashm., *Limnerium fugitivum* Say, *Amelotonus clisiocampæ* Weed, *Anomalon exile* Prov., *A. anale* Say, *Spilocryptus extrematus* Cress., *Rhogas intermedius* Cress., *Bracon gelechiæ* Ashm., *Diglochis omnivorus* Walk.,

^a Tech. Bul. No. 6, N. H. College Agric. Exp. Sta., p. 2 (1903).

Theronia melanocephala Brullé (?), and the dipteran *Frontina frenchii* Will.

Among predaceous insects are several species of ground beetles which are said to feed upon the larvæ, among them *Calosoma scrutator* Fab. Among the Hemiptera Mr. A. H. Kirkland has observed several species of *Podisus* attacking the larvæ (*Podisus placidus* Uhl., *P. modestus* Dall., and *P. serieventris* Uhl.) and the rudiviid *Diplodus luridus* Stål. Also, according to Professor Bruner, *Podisus spinosus* Dall. and *Perillus claudus* Say are enemies of the caterpillars.

While most birds, as a rule, do not feed on hairy larvæ, such as the tent caterpillar, yet several species are known to include this insect in their diet, as the black-billed and yellow-billed cuckoos, the bluejay, and, according to Mr. E. H. Forbush, the crow, chickadee,

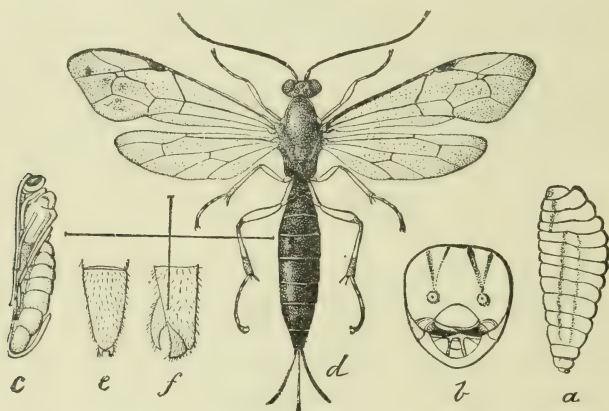


FIG. 3.—*Pimpla conquisitor*, an important parasite of the tent caterpillar: a, Larva, enlarged; b, head of same, still more enlarged; c, pupa; d, adult female, enlarged; e, f, end of abdomen of adult male, still more enlarged. (From Fourth Rept. U. S. Entom. Comm.)

Baltimore oriole, red-eyed vireo, chipping sparrow, and yellow warbler. Kirkland states that the common toad feeds greedily on tent caterpillars, he having found in their stomachs the remains of from 15 to 20, and in one instance 37 of these larvæ.

The caterpillars are also subject to destruction by a bacterial disease, especially when they become grown or nearly so, and sick, sluggish individuals may often be observed lying outside at full length on the nest. Larvæ killed by this disease are soft-bodied, the skin easily rupturing and permitting the escape of the liquid decomposed body contents.

METHODS OF CONTROL.

Removal of useless trees.—As has been stated, the unsightly nests of the tent caterpillars are especially apt to be found on wild cherry, apple, and other trees growing along roadsides, fences, and elsewhere.

In most cases such trees could doubtless be removed without disadvantage, and their removal would greatly reduce the numbers of this pest by lessening their favorite food supply.

Collecting the eggs.—During the dormant period of trees, when the leaves are off, the egg masses are fairly conspicuous, and with a little practice may be readily found; it is then that they should be cut off and burned. Trees infested with larvæ during the early part of the year, or those in the immediate vicinity, are perhaps more likely to be chosen by the parent moth for the deposition of her eggs, and such trees at least should be searched if it is not practicable to extend the work to the orchard as a whole. This work may be combined with pruning to good advantage, and a lookout should be kept not only for the eggs of this insect but for the eggs and cocoons of other injurious species which pass the winter on the trees.

DESTROYING THE CATERPILLARS.

Neglect to search out the egg masses during the winter will result in the appearance of the larvæ about the time the trees are putting forth foliage. The nests, at first small, are soon so increased in size as to attract attention. If the caterpillars are destroyed as soon as the small nests are detected, this will prevent further defoliation of the trees, and the rule should be adopted to destroy them promptly as soon as discovered. In this work either of two practices may be resorted to, namely, destruction by hand or with a torch.

When in convenient reach the nests may be torn out with a brush, with gloved hand, or otherwise, and the larvæ crushed on the ground, care being taken to destroy any caterpillars which may have remained on the tree.

The use of a torch to burn out the nests will often be found convenient, especially when these occur in the higher parts of trees. An asbestos torch, such as advertised by seedsmen, will be satisfactory, or one may be made simply by tying rags to the end of a pole. The asbestos or rags are saturated with kerosene and lighted and the caterpillars as far as possible cremated. Some caterpillars, however, are likely to escape, falling from the nest upon the application of the torch. In using the torch great care is necessary that no important

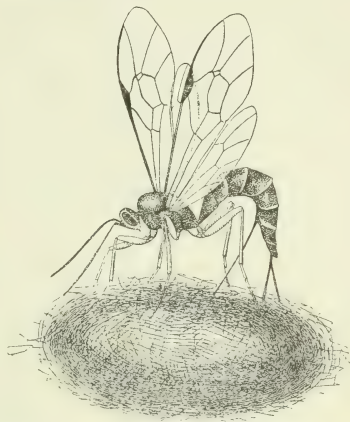


FIG. 4.—*Pimpla* in the act of ovipositing on cocoon of tent caterpillar. Somewhat enlarged (after Fiske).

injury be done the tree; it should not be used in burning out nests except in the smaller branches and twigs, the killing of which would be of no special importance. Nests in the larger limbs should be destroyed by hand, as the use of the torch may kill the bark, resulting in permanent injury.

Spraying with arsenicals.—Tent caterpillars are readily destroyed by arsenicals sprayed on foliage of trees infested by them. Dr. H. T. Fernald's careful experiments and those of Professor Lowe in determining the amount of poison necessary to kill the caterpillars show that the latter are very sensitive and are killed in from two to three days by the use of Paris green at the rate of 1 pound to 300 or 400 gallons of water.

Orchards or trees sprayed with arsenicals in the spring for the codling moth, cankerworms, or similar insects will be kept practically free from tent caterpillars, and this species rarely requires attention at the hands of the up-to-date commercial fruit grower. It will be troublesome in the scattered trees around the home or in the small orchard which is not regularly sprayed. On such trees the nests will likely be in evidence every spring, and during occasional years the caterpillars may be excessively abundant, completely defoliating the trees.

Even in the small home orchard of a dozen or more trees it will be found highly profitable to adopt a system of spraying which will control not only tent caterpillars but such serious pests as the codling moth, cankerworms, various bud and leaf feeding insects, and will greatly reduce injury from the curculio.

Any of the arsenical insecticides may be used, as Paris green, Scheele's green, arsenate of lead, etc. The former two are used at the rate of 1 pound to 150 or 200 gallons of water, and the latter at the rate of 2 pounds to 50 gallons of water, the milk of lime from an equal amount by weight of stone lime, as poison used, being added to neutralize any caustic effect of the arsenical on the foliage. Preferably, however, the poisons should be used in Bordeaux mixture, thus effecting a combination treatment for insects and fungous diseases. On stone fruits, such as cherry, peach, and plum, arsenicals are likely to cause injury to foliage and must be used with caution if at all. On such trees the arsenate of lead is preferable, as it is less injurious to foliage, and on all trees sticks much better. In spraying for the tent caterpillar only, applications should be made while the caterpillars are yet small, as these succumb more quickly to poisons than when more nearly full grown, and prompt treatment stops further defoliation of the trees.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., December 3, 1907.

[Cir. 98]

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

THE NUT WEEVILS.^a

By F. H. CHITTENDEN, Sc D.,

Entomologist in Charge of Breeding Experiments.

INTRODUCTION.

Nut-growing in the United States would be a much more profitable industry were it not for the insects which inhabit the kernels, rendering them unfit for food. This is especially true of the chestnut and chinquapin and to a lesser extent of pecan, hickory, and hazel nuts; while others, which include butternuts, walnuts, and almonds, suffer little or no injury from this source. Considerable diminution in the yield of many forms of nuts is also caused by the inroads of insect larvæ in the growing husks. Examples of the first class are the chestnut "worms" or weevils; of the second, the husk-worms and walnut curculio. The present paper will be restricted to a consideration of the weevils.

The chestnut crop suffers the greatest loss, and the chief depredators are the grub-like "worms" or larvæ with which everyone is too distressingly familiar. These larvæ develop with the nuts, so that those which first attain maturity are ready to leave and enter the ground nearly as soon as the nuts

are gathered; others remain in the nuts some weeks later; so it frequently happens that when nuts are packed for shipment in bags or barrels, some nuts which were apparently sound

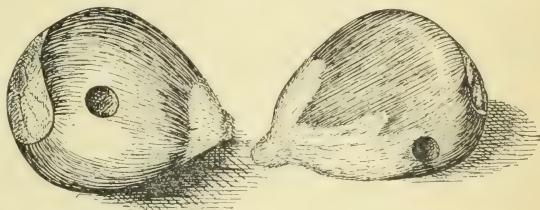


FIG. 1.—Chestnuts showing exit holes of chestnut weevil larvæ. Enlarged one-fourth (author's illustration).

when shipped are found, on reaching their destination, with one or more holes in their shells (fig. 1), while the repulsive grubs crawl about at the bottom of the receptacle. How to cope with these weevils has long been a most vexatious problem.

THE CHESTNUT WEEVILS.

In comparatively recent years chestnut culture has assumed considerable proportions, and has taken a new impetus since the extensive introduction and development of Japanese and European varieties. These are grafted on American seedlings or native stocks, and thus many valueless trees on equally unpromising soil are converted into

^a Reprinted from Yearbook of the Department of Agriculture for 1904, pp. 299-310, Pls. XXVIII-XXX, text figs. 17-26.

sources of profit. Were it not for the "worms," "borers," and "blights," chestnut growing might develop into a most lucrative industry in regions adapted to it.

ESTIMATES OF LOSSES.—A fair estimate of the damage done annually by weevils to chestnuts grown in the United States would probably fall little short of 25 per cent, while in some years the percentage exceeds that figure, running as high as 40 or 50 per cent. Growers in some localities report no damage, others place losses as low as 5 or 10 per cent, while instances are cited of whole crops being destroyed. The amount of loss is dependent on locality, season, and to a more limited extent on the variety of nuts grown. The greatest damage is usually incurred in regions where chestnuts have grown wild for many years, and the least where there are no wild chestnuts or chinquapins and the nuts are grown only for market and are carefully gathered. The most extensive losses, judging from available sources of information, appear to be in Massachusetts, Pennsylvania, New Jersey, New York (in the vicinity of New York City), Delaware, Maryland, Virginia, Tennessee, and North Carolina.

In Georgia, Spanish and Japanese varieties have been cultivated for years without attack by weevils being noticed. In New Jersey, 50 per cent of the same varieties have been ruined. A grower in Missouri has reported no damage to 50 trees of an American variety; another at South Haven, Mich., has reported no injury for a period of three or four years to Japanese and Spanish chestnuts grown there, while from 5 to 20 per cent of the crop of native nuts was annually destroyed. The nearly complete destruction of the chestnut crop of New Jersey for 1893 was reported.

THE SPECIES OF CHESTNUT WEEVILS.—The species of weevils which infest chestnuts are two in number—the larger chestnut weevil, *Balaninus proboscideus* Fab., and the lesser chestnut weevil, *B. rectus* Say. They have extremely long, slender beaks or snouts, nearly as fine as a horsehair, and considerably longer than the body in the female. By means of this long beak the female is able to penetrate the thickest burr of the chestnut with its long spines and to cut out, with the minute and sharp mandibles at the tip of her beak, a little hole for the deposition of her eggs. These are inserted through the husk into the growing nut.

The two species resemble each other greatly in color and in markings, the general color of both being golden yellow, ochraceous, or clay yellow, frequently tinged with olive, and a little paler on the lower surface. The disk of the thorax is a little darker, with a wide bright band on each side, and the elytra, or wing-covers, are mottled with rich light brown or dark brown markings of variable size and extent.^a

^a Occasional individuals lack the darker markings, some being paler, others darker, even reddish. The ground color, as may be seen in abraded specimens, is really black, and the apparent color is due to scales very similar to those of butterflies and moths.

THE LARGER CHESTNUT WEEVIL.

(Balaninus proboscideus Fab.)

The larger chestnut weevil (fig. 2) is considerably the larger and more robust species. The female rostrum or beak, although proportionately of about the same length as in the lesser weevil, is perceptibly more prominent because less curved, the curvature being toward the tip. It is also more widened at the base. The body measures from one-third to nearly one-half of an inch in length, and the beak of the female is often five-eighths of an inch long. That of the male (fig. 2, *c*) is nearly as long as the elytra. The egg is small, about one-sixteenth of an inch long, and of the outline shown in figure 3, *d*. It is nearly white, partially translucent, and without sculpture.

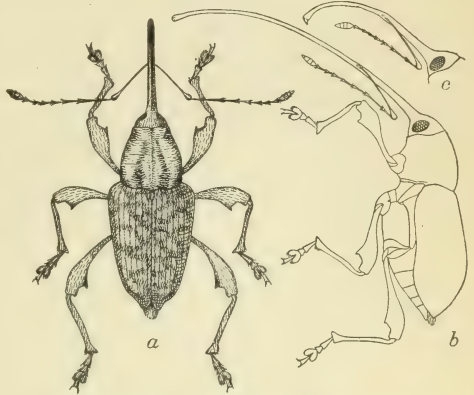


FIG. 2.—The larger chestnut weevil (*Balaninus proboscideus*): *a*, Female beetle; *b*, same in outline from side; *c*, head, rostrum, and antenna of male. Three times natural size (author's illustration).

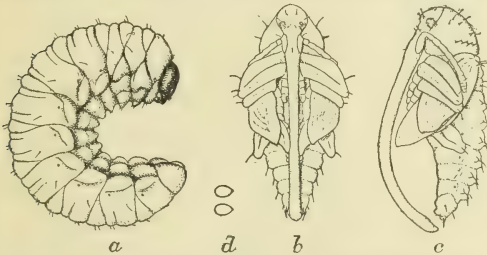


FIG. 3.—Larger chestnut weevil (*Balaninus proboscideus*): *a*, Larva; *b*, *c*, female pupa; *d*, eggs. All enlarged (author's illustration).

The larva (fig. 3, *a*) is milk-white, robust, fully three times as long as wide, with the dorsal or upper portion rounded and convex. The entire surface is very strongly wrinkled transversely, and there are a few very short hairs scattered sparsely over the different segments. The head (fig. 4) is about one-fourth as wide as the widest portion of the body. It is provided with short but strong mandibles, by means of which it gnaws the kernel constituting its food. The fully developed larva in ordinary resting position measures nearly half an inch. Although the larva has no true legs, it is able to crawl, slowly and clumsily, it is true, by means of the flattened lower surface, locomotion being aided by transverse wrinkles.

The pupa is of a clearer whitish color than the larva, and shows the principal external organs of the body of the future beetle, all, except the beak, folded tightly to the body. The female pupa is illustrated in figure 3, *b*, *c*.



FIG. 4.—*Balaninus proboscideus*: Head. Much enlarged (author's illustration).

This species, like the other weevils under consideration, is native to America and is known from Rhode Island to Virginia, the District of Columbia, southern Ohio, and Tennessee, and westward to Kansas. The geographical distribution of this and the other nut weevils has as yet not been carefully studied, but in all probability it is considerably more extensive than above stated.

In some regions this species is quite generally known as the chinquapin weevil, but the investigations conducted during 1904 indicate that, although it breeds in chinquapins and more commonly in chestnuts, it occurs in greater abundance in the larger imported nuts.

THE LESSER CHESTNUT WEEVIL.

(*Balaninus rectus* Say.)

The lesser chestnut weevil (fig. 5) has the scape of the antenna longer than in the preceding species and the first joint longer than the second.^a The average length of the body is about one-fourth of an inch, but the size varies, as in all of these insects.

The distribution of this species extends from Canada and Massachusetts to North Carolina, Tennessee, and Ohio, and probably farther westward. The writer has seen sets of specimens labeled "Arizona." Although in some localities the larger species is much more in evidence, taken all in all, the lesser weevil is the more com-



FIG. 5.—Lesser chestnut weevil (*Balaninus rectus*) adult: a, Female, dorsal view; b, female, lateral view; c, head of male. Much enlarged (author's illustration).

mon and is probably even more widely disseminated.

The egg has not come under observation, but is undoubtedly very similar to that of the preceding, being proportionately smaller, which is true of the remaining stages.

The larva is only a third of an inch long and its length is about three times its width. The body is milk-white and the head light brownish yellow, while the α -mark has a short lateral branch each side.

The pupa differs from that of the larger species by size and by characters shown in figure 6, which illustrates the male.

^a In the larger species the first joint (omitting the scape) is shorter than the second. In the female *rectus* the rostrum is strongly curved, the thorax is longer than wide, and the elytra are strongly acuminate apically. The tooth with which the thighs are armed is small, with the entering angle rounded.

LIFE HISTORY OF BOTH SPECIES.

The life history of our two chestnut weevils is so similar as to be practically the same for both species. There are, however, minor differences. These, as well as related nut and acorn weevils, hibernate exclusively in the larval condition and in the soil. Both make their first appearance at about the same time—with the first blooming of chestnuts—but this period may vary from late in June to July, according to locality and season, or, more properly speaking, the mean temperature. At this time the beetles are found rarely and scatteringly, and as oviposition has not been observed then it is doubtful whether it begins until considerably later. What function these early arrivals fulfill is problematical. The beetles increase in number as the nuts approach maturity, or until about the middle of September or a little time before the nuts are first marketed. Then they may be seen in greater abundance, several pairs, frequently of both species, often occurring on a single bunch of burrs (fig. 8). As it requires about two weeks for the egg to develop, it is not probable that they are laid much earlier than when the nut begins to form. From examination of many burrs gathered in the fall of 1904 by Mr. F. C. Pratt, of the Bureau of Entomology, who visited some of the principal chestnut groves of Pennsylvania and Virginia at the urgent request of growers in those States, it is deduced that the first eggs deposited are laid (seldom and very sparingly) in the soft, woolly material surrounding the forming nut; but later they are inserted in the kernel just under the inner skin, and occasionally they are deposited somewhat more deeply. In no case has the egg been found in the outer husk.

Eggs are laid singly, but many are placed in a single nut, as high as 40 or more (of the smaller weevil) in imported nuts, and as many as 9 in native nuts. The larvæ when hatched feed on the tissue of the growing kernels, enlarging with their own growth the cells thus made. When, as is usual, several larvæ inhabit the same nut, the interior is more or less completely hollowed out, and large masses of excrement are left behind (fig. 9).

By the end of September or the first week of October the beetles disappear. At about the same time, when the nuts first fall, the larvæ begin to mature and issue from round orifices which they gnaw through the shell and which vary in diameter from one-sixteenth of an inch, in the case of the smaller species, to one-eighth of an inch in the larger (see fig. 7). By the size of these holes alone it can be readily determined which species is the dominant one in any given locality. Rarely

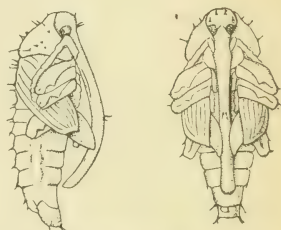


FIG. 6.—Lesser chestnut weevil (*Balaninus rectus*): Pupa, from side, at left; ventral view at right. Enlarged (author's illustration).

larvæ bore through the burr. On leaving the nuts they burrow into the earth to depths varying from 2 to about 8 inches, according to the hardness of the soil. If confined in soft earth or sand they penetrate still deeper. The larval period probably lasts from three to five weeks in the nuts, and about ten months in the earth, pupation taking place

within three weeks of the issuance of the beetle, the latter remaining several days in the earth before appearing above ground.

The beetles do not fly readily, but cling tightly to their resting place or drop when disturbed; yet, as their bodies are not heavy and their wings strong, they are obviously able to cover considerable distances, especially with the wind. Ordinarily, however, they are sluggish,

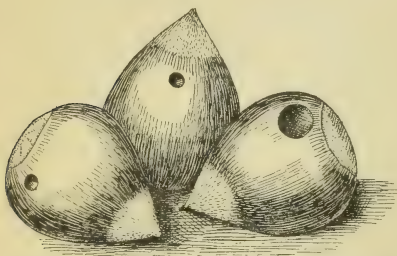


FIG. 7.—Chinquapins, showing injury by lesser chestnut weevil at left; of larger weevil at right. Enlarged (original).

like most other weevils, and probably do not go far from the vicinity of the trees which have sheltered them as larvæ, although they undoubtedly migrate when food is scarce.

NATURAL ENEMIES.

A natural enemy of the nut weevils is known, a small four-winged wasplike fly, the braconid parasite *Urosigalphus armatus* Ashm., which develops in the body of the larva.^a

METHODS OF CONTROL.

The most practical remedy for nut weevils that can be suggested is the early destruction of the "worms" in the nuts by means of bisulphid of carbon and the observance of clean orchard management and other cultural methods. It may be well to preface the discussion of these methods with a statement of the uselessness against nut weevils of ordinary measures employed in the control of similar insects.

UNSATISFACTORY METHODS.

STOMACH POISONS.—The peculiar structure, in the nut weevils, of the mouth-parts (minute mandibles placed at the end of a beak nearly as fine as horsehair and as long or longer than the body) is almost sufficient proof in itself that these insects do not feed on leaves, but depend for sustenance on the substance of the growing nuts. The beetles first appearing feed on the undeveloped, very young nuts and the juices within the husk. There is, therefore, no seeming possibility of reaching them with a spray of Paris green or other stomach poison.

^a Two other insects are associated with the weevils and are probably also their enemies, a proctotrypid parasite, *Trichasis rufipes* Ashm., and a predatory reduviid bug, *Acholla multispinosa* DeG.

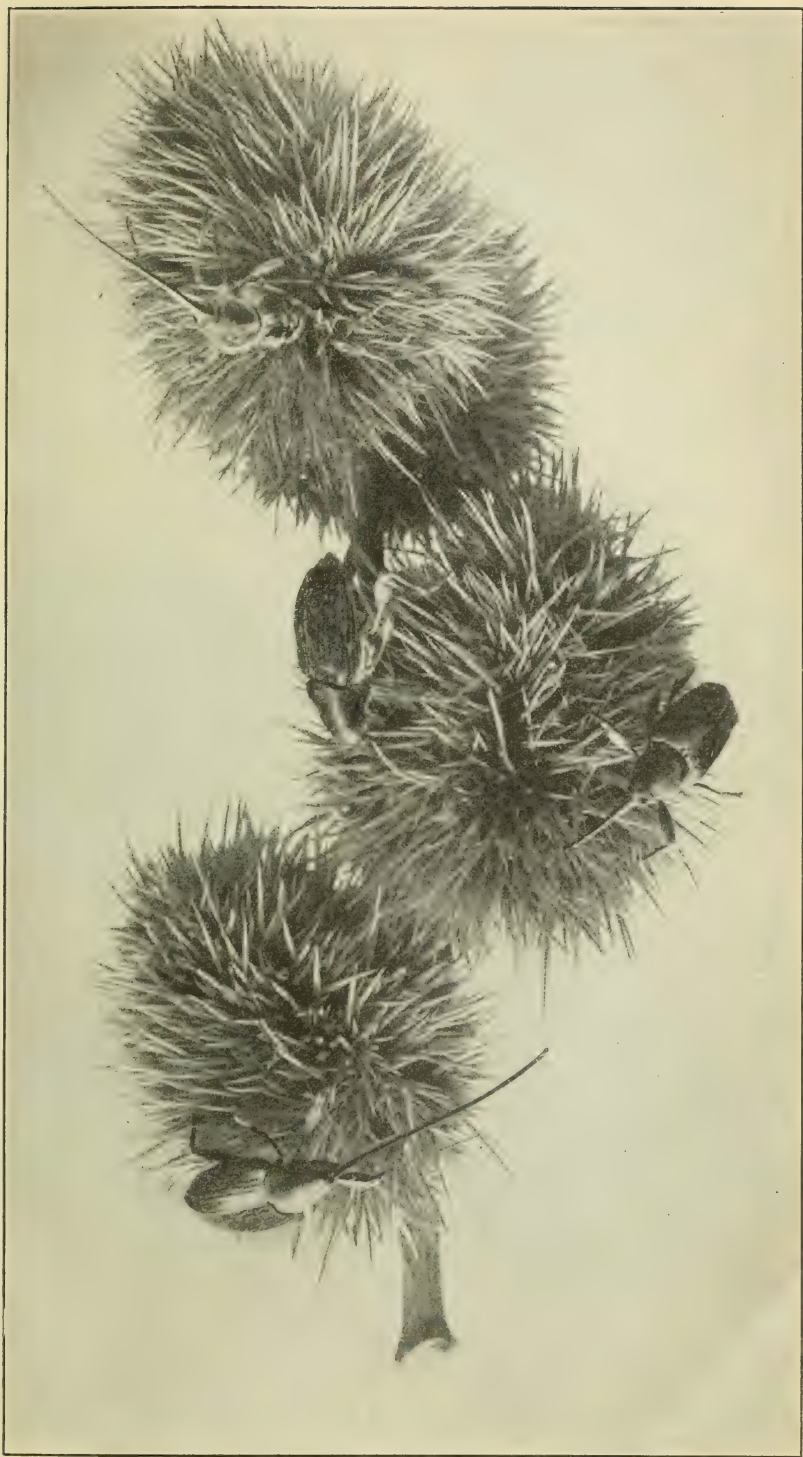


FIG. 8.—Larger chestnut weevil on chinquapin burrs. Twice natural size (original).
[Cir. 99]

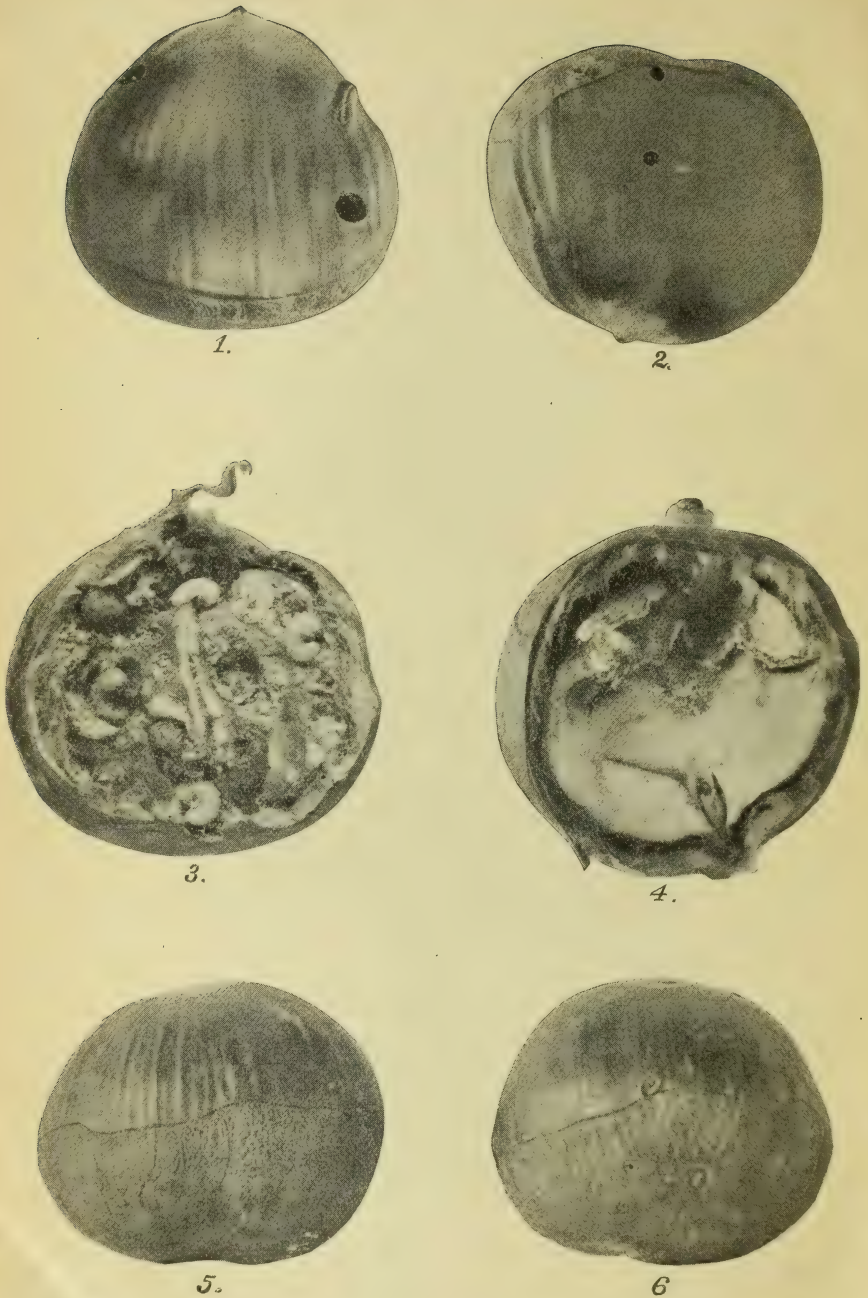


FIG. 9.—Imported nuts, showing different forms of injury by nut weevils. 1—Parry's Giant nut, showing exit hole of *Balaninus proboscideus*; 2—Same of *B. rectus*; 3—Interior of Paragon nut, showing larvæ of *B. rectus* in situ; 4—Same, showing work of one individual of *B. proboscideus*; 5—Reverse side of figure 2, showing scars made by puncture of female *B. rectus* in ovipositing; 6—Reverse of figure 1, with puncture of *B. proboscideus*. All natural size (original).

particularly as we are unable to place the insecticide where they would eat enough to kill them.

TRAP CROPS.—The cultivation of special varieties of nuts with a view to securing immunity from attack or as a means of luring the insects from the main crop does not offer any degree of promise. The Paragon, Cooper, and Ridgeley varieties, according to Mr. G. H. Powell, of the Bureau of Plant Industry, suffer greater loss from weevil attack than Japanese varieties. Chinquapins are favored by the smaller weevil and suffer far more damage, as a rule, than wild chestnuts. It is possible that the planting of the varieties specified, or, better, of chinquapins, at intervals around, as also through, orchards of the least affected varieties might lessen the loss to the main crop. If a variety could be produced which would mature fruit before the advent of the beetles in greatest numbers, this would partially solve the problem, particularly as the earliest nuts bring the highest prices. The nuts gathered toward the end of the season are comparatively uninjured, but by this time the market value is considerably lower.

CONTACT POISONS.—Scarcely more can be expected from the use of contact poisons, such as kerosene emulsion, since in view of the long period spent by these weevils in the adult stage (from June and July to September or October) such frequent application would be necessary that the expense would destroy the profit.

JARRING THE TREES, as practiced against the plum curculio, is for the same and other reasons equally impracticable, save, perhaps, on young trees grown in a small way.

THE WATER TEST OF INFESTATION.—Having doubts of the efficacy of this old-fashioned test of the difference between “wormy” and healthy nuts, an experiment was made by the writer with native chestnuts obtained from a street vender. To begin, 40 per cent were obviously “wormy,” and only 60 per cent apparently sound.

Results of water tests with native chestnuts.

Nuts which rose to surface.		Nuts which remained on bottom.	
	<i>Per cent.</i>		<i>Per cent.</i>
Uninfested.....	10	In perfect condition.....	40
Showing minute marks only; good flavor; salable.....	20	Slightly injured.....	30
Containing full-grown grubs.....	10	Badly infested.....	20
Containing immature grubs.....	60	Completely filled with grubs.....	10

As will be seen from this experiment, noticeably wormy nuts, as evidenced by loss of weight and the exit holes of the “worms,” naturally rise when placed in water, but the remaining nuts may or may not be infested, and hence require further test than whether they will sink or float.

DIRECT REMEDIES.

BISULPHID OF CARBON.—The value of bisulphid of carbon as a fumigant for chestnuts infested by weevils is now fully established. Although at first thought it would seem difficult for the gas to penetrate through shells so firm and compact and kill the larvæ, nevertheless a prominent grower in Pennsylvania successfully uses the bisulphid, applying it when the nuts are first harvested. The dead weevil larvæ are at this time so small that the average person would never detect their presence, while if they were permitted to develop they would soon destroy the nut for food. Bisulphid of carbon has been used on the largest chestnuts grown in this country, and, since a score or two of larvæ find shelter in a single nut, one can appreciate the desirability of prompt fumigation. The grower mentioned uses bisulphid of carbon at the rate of 1 ounce to a bushel of Paragon nuts placed in a kerosene barrel of about 50 gallons capacity and covered by sacking. After an exposure of about sixteen hours the nuts are removed, the larvæ being then practically all destroyed. Several hundred pounds were treated in 1904 in this manner with perfectly satisfactory results. To verify reported results, Mr. Pratt was detailed to visit the infested orchard and witness the process. This method could be employed at less expense by using tightly fitting covers, the effectiveness of the fumigation being in exact proportion to the tightness of the receptacle and the length of exposure to the fumes. Therefore, a longer exposure of one or two days, with perhaps one-half ounce of bisulphid, should accomplish the same purpose.

SCALDING AND DRYING.—Some growers make a practice of plunging the nuts as gathered into boiling water just long enough to kill the contained insects and yet not injure the nuts for sale, after which they are dried before being marketed. This may be profitably accomplished by using a large sieve, which is filled with nuts, dipped in the water, and removed in about five minutes. The late W. P. Corsa used a washtub, in which was placed a bushel or so of nuts, pouring in enough boiling water to come an inch or two above the nuts. Then, by stirring vigorously with a stick, the bulk of the weevilly nuts would come to the surface in the same manner as do peas and beans affected by weevils.^a The infested nuts are skimmed off and destroyed, or they may with profit and safety be fed to hogs, provided the animals do not have a too exclusive diet of this form of food. Salt water, it is claimed, is preferable for scalding, the brine serving to keep the shell soft and pliable and rendering the kernels more palatable than when not thus treated.

Different methods are employed in drying. A good way is to place the nuts in the sun and agitate them occasionally by stirring or

^a Note the writer's observations on this head on p. 9.

shaking in a bag until thoroughly dry, because if moisture remains unevaporated it is apt to form mildew when the nuts are prematurely packed for shipment.

Nuts for planting should not be scalded, and care should be taken not to cook the kernels of nuts intended for sale. Some growers claim that the hot-water treatment is objectionable because the nut-shells lose a certain degree of polish, rendering them less desirable for market.

HEAT.—Infested nuts can be subjected to a temperature of between 125° F. and 150° F. without injuring them for food or for seed, and this will effect the destruction of the larvæ within. Some growers of chestnuts destroy the weevils by kiln-drying.

COLD STORAGE.—Cold storage has been employed and is successful in arresting the development of the larvæ. The appearance of the nuts is scarcely different from that of those not so stored, but nuts thus treated and submitted to the writer after becoming dry were deficient in flavor, having an acrid and moldy taste.

A crude form of cold storage has been successfully followed by a Virginia grower. It consists in placing nuts in the earth under the shade afforded by his house, where the soil temperature, after the nuts are gathered, does not exceed 50°. Since most insects are inactive below 51° this has the effect of restraining their development, causing the eggs or minute larvæ to die.

PREVENTIVES.

CHOICE OF LOCATION FOR THE ORCHARD.—The selection for the planting or grafting of chestnuts of a locality with reference to the chances of immunity from injury by nut weevils is a matter of great importance. For this reason it is most undesirable to plant in the immediate vicinity of woodland abounding in wild chestnut and chinquapin, since these trees furnish natural breeding places for the insects, and are, therefore, a constant menace to successful chestnut culture. Too frequently growers suffer losses from weevils because they neglect to gather the wild chestnuts or chinquapins in the immediate vicinity of their cultivated groves. Another phase of bad management which is frequently practiced is the grafting of cultivated varieties on native chestnuts growing in rocky and uneven soil, often on hillsides, as shown in figure 11. In such places it is impossible to harvest a complete crop, and, what is of equal importance, to gather the remnants. Hence, to secure these results, it is imperative to plant or graft trees on smooth ground (fig. 12), first for the sake of economy, and second to permit the collection of all of the nuts, leaving none for the propagation of weevils. It is also necessary to keep the soil clean of herbage, as shown at the left of figure 12—not overgrown with brush, as illustrated at the right.

CAREFUL HARVESTING.—It is always advisable to gather the entire crop, leaving none on the ground, and either place the nuts in tight receptacles or fumigate with bisulphid of carbon before marketing. The grubs crawl out soon after the nuts have been gathered, and as they require considerable moisture they will die if confined in closed barrels or boxes. The trouble is that enough nuts are usually left in orchards or in adjoining wood or forest land to serve for the propagation of the insects the following year. In order to make the method of treatment here described thorough, it will be necessary to secure the cooperation of neighboring landowners who grow chestnuts for market and of all who own woodland containing chestnut and chinquapin.

The collection of remnants can be made by children or the unemployed. It is also profitable to allow hogs the run of the orchards to destroy what nuts remain after the crop has been harvested. In the mountainous sections of Virginia and Pennsylvania it is a common practice to fatten swine on the unpicked fallen nuts. Hogs fatten on nuts and acorns as well as on corn, and without expense to the grower.

COOPERATION.—The results of the observance of clean farming on the lines that have been indicated may not at once be apparent, but in course of time, if this work is systematically carried out by all growers over a considerable territory, infestation will be very materially decreased. An important point is to ascertain how far the insects fly. Their structure indicates that they are strong fliers and capable, with favoring winds, of migrating considerable distances; but under ordinary circumstances they probably do not fly many miles at a time or in a given year.

THE PECAN WEEVIL.

(*Balaninus caryæ* Horn.)

With the increase of pecan culture in our southern States frequent inquiry is made in regard to the cause of the holes in the nuts

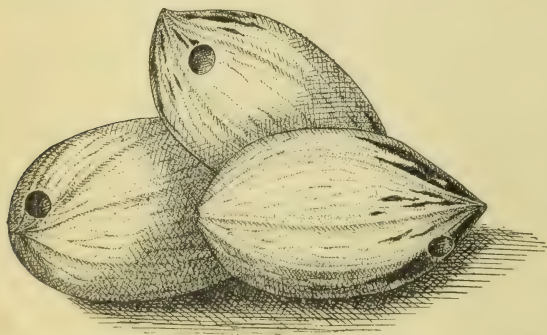


FIG. 10.—Pecan nuts showing exit hole of pecan weevil larvæ. One-third enlarged (author's illustration).

(fig. 10), and during 1903 and 1904 there were reports of great injury of this nature, more particularly to pecans grown in Texas, where considerable loss was reported, and in Georgia, where in one locality 75 per cent of the crop was a failure.

A shortage has also been reported in Mississippi. The insect involved in these cases is the pecan or hickory-nut weevil, a pest which is evidently destined to become one of the



FIG. 11.—Paragon chestnut orchard, growing on hillsides, showing impossibility of clean orchard management.



FIG. 12.—Paragon chestnut growing on plane surface, where clean methods of cultivation can be practiced.

[Cir. 99]

principal drawbacks to the cultivation of the pecan. Indeed, in many parts of the South it already divides that distinction with the husk-worm, so that it has been truthfully said that what the husk-worm leaves the weevil destroys.

The beetle (fig. 13) is about the same size as the larger chestnut weevil, from which it may be distinguished by its much duller color ^a and by the relative lengths of the first and second antennal joints, the first joint being longer than the second in the pecan-infesting species.

The larva differs from that of *proboscideus* in being decidedly yellow, having the head bright red and wider than long. Its cervical plate also is darker. The pupa is similar to that of the larger chestnut weevil.

The distribution extends from New York to the Gulf, and westward at least to Iowa.

The life history of this weevil, as it occurs in the pecan in the South, is, so far as can be gathered from reports from Georgia and Texas and from laboratory experiments, very similar to that of the chestnut weevils. According to the ob-

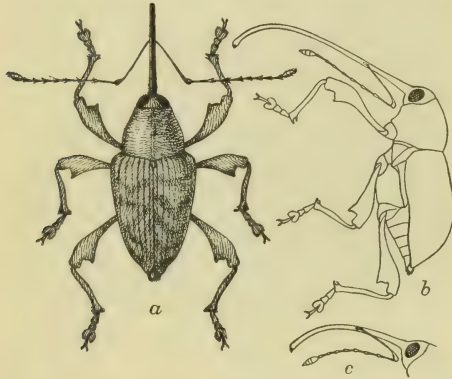


FIG. 13.—Pecan weevil (*Balaninus caryæ*): a, Female, dorsal view; b, same, lateral view, in outline; c, head with rostrum and antenna of male. About two and one-half times natural size (author's illustration).

servations of Mr. H. A. Halbert, at Coleman, Tex., the female begins to deposit her eggs in August while the pecan is still immature, and the larva usually escapes from the nuts in the latter part of September and in October; but most of them do not issue until the husks open, allowing the nuts to fall. In Georgia they have been found in the nuts as late as the middle of January.

REMEDIES.

The same care in the selection of the site for a pecan orchard is advised as in the case of chestnut culture, with this difference, that the grower should avoid planting in the vicinity of wild pecan and hickory of whatever kind. The entire crop, also, should be harvested or hogs should be turned in to devour what nuts are left. At Thomasville, Ga., Mr. Wilmon Newell observed in 1904 that where swine and chickens had had access to a pecan grove, the ground was well rooted and scratched up and there was less loss from weevils than in the pre-

^a The ground color is uniform dark brown, nearly black, and the scaly covering (which characterizes the chestnut weevils) in this species is hair-like on the thorax, fine and somewhat sparse on the wing-covers, and much duller, with little or no mottling. Moreover, the beak of the female is, comparatively, a little shorter, although of about the same curvature, and is less widened at the base.

vious year. Evidently both hogs and poultry devour the larvæ in the ground.

At the time that bisulphid of carbon was first suggested as a remedy for chestnut "worms" it was feared that the firm and compact shell would hardly permit the gas to penetrate and kill the contained larvæ. Experience, however, has shown that this remedy is successful in the case of chestnuts, and it is not impossible that it might be adapted to pecans, using a larger amount of the chemical and a longer exposure in a perfectly tight receptacle. We can as yet scarcely advise this method on a large scale, but it should certainly be tried experimentally.

THE HAZELNUT WEEVIL.

(*Balaninus obtusus* Blanch.)

Hazelnuts or filberts are injured in much the same manner as are chestnuts and pecans and by a similar weevil. Injury was recognized as early as 1841, but was attributed to other species than that under consideration. Owing to the comparatively slight importance of the hazel as a nut tree in this country, few notices of losses from weevil attack have been recorded. The weevil which affects the nut was not differentiated from others of its kind until 1884. In 1891 it was reported as badly damaging hazelnuts in Iowa.

The beetle (fig. 14) differs from others which attack edible nuts, exclusive of acorns, by its shorter, more robust form and shorter beak.^a It is about one-fourth of an inch in length, and the beak does not exceed half the length of the body. The vestiture varies from gray to ochreous, and the elytra are moderately mottled.

This species occurs from Massachusetts and New Hampshire westward to Minnesota and Texas. Injury has been noted in Massachusetts, New York, Indiana, Iowa, and Minnesota.

Of the life history little has been recorded beyond the fact that the "worm" issues from the side of the nut, and that paired adults have been found on hazelnuts in July.

REMEDIES.

Since hazels are not cultivated in this country to any extent, no remedy need be employed other than gathering entire crops and destroying isolated bushes where it is unprofitable to gather the nuts. It would be quite possible, owing to the small size of the hazel plant, to control this species by jarring, as for the plum curculio.

^a The appendices of the claws are broadly rectangular, and the femora or thighs are armed with large teeth. The scape of the antenna in the female is long.



FIG. 14.—Hazelnut weevil (*Balaninus obtusus*), adult: a, Female, dorsal view; b, head from side; c, head of male from side. Enlarged (original).

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Issued November 2, 1911.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—CIRCULAR No. 100.
L. O. HOWARD, Entomologist and Chief of Bureau.

AN INDEX TO CIRCULARS 1 TO 100 OF
THE BUREAU OF ENTOMOLOGY.

BY

ROLLA P. CURRIE AND ANDREW N. CAUDELL.

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United States Department of Agriculture,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

AN INDEX TO CIRCULARS 1 TO 100 OF THE BUREAU OF ENTOMOLOGY.

By ROLLA P. CURRIE and ANDREW N. CAUDELL.

The first circular of the present series, or what was formerly known as the second series, of the Bureau of Entomology was issued in 1891, while Circular 99 was issued in 1908. The circulars of the first series, something over 40 in number, were nearly all merely circular letters and had only a temporary value. Very few of these first-series circulars are now known to exist, and even the titles of most of them are now unknown.

While some of the circulars of the present, or second, series were in the nature of emergency circulars, and were therefore soon discontinued or superseded, yet very many others were popular summaries, containing in condensed form all the important data available concerning the particular insects discussed. They have therefore a distinct value to the student and worker in economic entomology as well as to the farmer, forester, horticulturist, and general reader. Many of the insects treated have not yet been made the subjects of bulletins or been considered in other publications of the department, and much information contained in these circulars is therefore not to be found elsewhere.

To make this information more easily available and to prevent it from being overlooked, the present index has been prepared, and it is hoped that it will be of use to all who read or consult the circulars of the bureau.

For convenience the index itself is preceded by a list of circulars 1 to 100, with their revisions. This list may be considered as complete and final, since the policy of issuing revised editions of circulars, i. e., under the original serial number, has been discontinued and no more such will be published.

Where circulars have gone through one or more revised editions the latest edition is the one indexed.

LIST OF CIRCULARS 1 TO 100 OF THE BUREAU OF ENTOMOLOGY

- No. 1. Condensed information concerning some of the more important insecticides. pp. 7. May, 1891.
- No. 2. The hop plant-louse [*Phorodon humuli* Schr.] and the remedies to be used against it. pp. 7, figs. 5, pl. 1. June, 1891.
- No. 3. An important enemy to fruit trees. The San Jose scale [*Aspidiotus perniciosus* Comst.]: Its appearance in the eastern United States; measures to be taken to prevent its spread and to destroy it. By L. O. Howard. pp. 10, figs. 5. April 4, 1893.
- No. 4. The army worm (*Leucania unipuncta* Haw.). By L. O. Howard. pp. 5, figs. 3. June 16, 1894.
- No. 5. The carpet beetle or "Buffalo moth" (*Anthrenus scrophulariæ* L.). By L. O. Howard. pp. 4, fig. 1. September 8, 1894.
- Same, revised edition. pp. 4, fig. 1. Issued August 10, 1908.
- No. 6. The Mexican cotton-boll weevil (*Anthonomus grandis* Boh.). By L. O. Howard. pp. 5, figs. 3. April 2, 1895.
- Same, Spanish edition. pp. 6, figs. 2. April 2, 1895.
- No. 7. The pear-tree psylla (*Psylla pyricola* Foerst.). By C. L. Marlatt. pp. 8, figs. 6. May 1, 1895.
- No. 8. The imported elm leaf-beetle (*Galerucella luteola* Müll.; *Galeruca xanthomelæna* Schrank). By C. L. Marlatt. pp. 4, fig. 1. May 23, 1895.
- Same, revised edition. pp. 6, fig. 1. Issued September 22, 1908.
- No. 9. Cankerworms [*Paleacrita vernata* Peck and (*Anisopteryx*) *Alsophila pometaria* Harr.]. By D. W. Coquillett. pp. 4, figs. 4. May 24, 1895.
- No. 10. The Harlequin cabbage bug, or calico bug (*Murgantia histrionica* Hahn). By L. O. Howard. pp. 2, fig. 1. May 24, 1895.
- No. 11. The rose-chafar [*Macrodactylus subspinosus* Fab.]. By F. H. Chittenden. pp. 4, fig. 1. May 21, 1895.
- Same, revised. pp. 4, fig. 1. Issued July 6, 1909.
- No. 12. The Hessian fly (*Cecidomyia destructor* Say). By C. L. Marlatt. pp. 4. July 26, 1895.
- Same, revised edition. pp. 4. April 13, 1900. (Superseded by No. 70.)
- No. 13. Mosquitoes and fleas. By L. O. Howard. pp. 4. February 1, 1896.
- Same, revised edition. November 15, 1897.
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United States Department of Agriculture,

BUREAU OF ENTOMOLOGY.

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THE APPLE MAGGOT OR "RAILROAD WORM."

(*Rhagoletis* [*Trypeta*] *pomonella* Walsh.)

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Five important insect pests injure the fruit of the apple in the United States, namely, the codling moth (*Carpocapsa pomonella* L.), the lesser apple worm (*Enarmonia prunivora* Walsh), the plum curculio (*Conotrachelus nenuphar* Hbst.), the apple curculio (*Anthrenus quadrigibbus* Say), and the species under consideration.

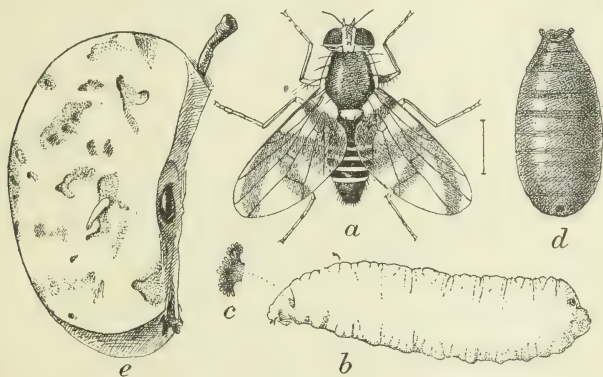


FIG. 1.—Apple maggot (*Rhagoletis pomonella*): a, Adult; b, larva or maggot; c, funnel of cephalic spiracle; d, puparium; e, portion of apple showing injury by maggots. a, b, and d, Enlarged; c, still more enlarged; e, reduced. (Original.)

The apple maggot, as the name implies, is the larva of a fly or dipterous insect, and belongs to the family Trypetidae, which group contains numerous other fruit-infesting maggots,^a some of them very serious pests, and, from their structure, mode of life, and feeding habits, very difficult of control. Apples injured or "railroaded" by the apple maggot show discolored winding burrows, or tracks, and

^a *Anastrepha* (*Trypeta*) *ludens* Loew., the so-called Mexican orange worm, is an enemy of oranges in portions of Mexico, infesting also the guava and mango, and *A. acidusa* Walk. infests the peach in the same country. *Rhagoletis ribicola* Doane infests currants and gooseberries in the United States, as does also *Epochra canadensis* Loew. *R. cingulata* Loew has recently been found to be a cherry pest in this country, working in a way similar to the European cherry fly, *Trypeta cerasi* L. (*signata* Meig.). *Ceratitis capitata* Wied., the so-

cavities here and there in the flesh, and when infested with several larvæ the pulp will be usually quite honeycombed with their burrows and more or less broken down into a yellowish mass, merely held together by the skin. (See fig. 1, *e*.)

DISTRIBUTION AND DESTRUCTIVENESS.

The apple maggot is a native American species, its natural food being haws (*Cratægus*), and in at least one instance it has been bred from crab-apples. Its feeding upon cultivated apples is thus an acquired habit, and although the insect has been reported from widely separated points in the central and eastern States, indicating its possible general distribution, for some reason it does not attack the apple throughout its range, but only in certain localities and portions of the country. This circumstance is a fortunate one for the apple grower, and from a scientific standpoint is of much interest. Walsh thought it might be explained on the supposition of the development in the New England States, where its injuries to apples were first noticed, of a race of apple-infesting individuals, the descendants of which, with the acquired habit, have been gradually distributed to other localities.

The apple maggot was described by Walsh in the *American Journal of Horticulture* for December, 1867, pages 338-343, and also in the *First Report of the Acting State Entomologist of Illinois*, from flies from eastern apples and from Illinois haws. Adult specimens from this latter fruit had been secured by him some five or six years earlier, and in July, 1867, he reared flies from maggots infesting apples from Connecticut, Massachusetts, and New York, and conclusively showed the identity of the insects infesting haws in Illinois with those infesting apples in the northeastern part of the United States. In the New England States mentioned, however, the species had been noted as an enemy of apple for some years before the time of Walsh's description. By 1866 it was common in the Hudson River country, at North Hempstead, Long Island, in the Oneida community in New York State, at East Falmouth, Mass., and probably in Vermont, and it occurred in Connecticut.^a

called Mediterranean fruit fly, or Bermuda peach maggot, is widely distributed, infesting a considerable variety of soft fruits, as oranges, peaches, plums, pineapples, and bananas, but fortunately has not yet been introduced into the United States. In Europe *Tephritis onopordinis* Fab. injures celery, and *T. tryoni* Froggatt seriously infests, in portions of Australia, bananas, peaches, oranges, etc., and another species of this genus (*psidi* Froggatt) in that country infests guavas. *Trypeta musæ* Froggatt seriously injures bananas in the New Hebrides. Some of these species are very general feeders, and the greatest care should be exercised, especially in the case of the Bermuda peach maggot, that they be not introduced into the United States.

^a First Rept. Acting State Ent. Illinois, pp. 29-33 (1867).

In 1881 the apple maggot was reported by Professor Comstock ^a from Ithaca, N. Y., in apples, and was bred by him from *Crataegus* at Washington, D. C. Professor Cook, ^b in 1884, received specimens from Delavan, Wis., where it was reported as doing very great injury, and the year following, the insect was the cause of considerable loss in Ingham and adjoining counties in Michigan.

Lintner, ^c in 1885, gives the additional localities of North Ashburnham, Mass., Franklin and Schenectady, N. Y., and Brandon, Vt. Its introduction into Maine, as stated by Professor Harvey, ^d occurred prior to 1882, by which time it had become well established, and by 1899 occurred quite generally over the State. Its occurrence at Montclair, N. J., was recorded in 1889 by Mr. E. Williams, in *Garden and Forest*, page 527, and this locality is also given for the apple maggot by Dr. J. B. Smith in his list of insects of New Jersey, page 687 (1899).

In 1894 Doctor Howard ^e records the occurrence of the apple maggot from Waynesville, N. C., and Doctor Fletcher ^f records its first appearance in Canada, August 31, 1896, in apples from Adolphustown, Ontario. As stated by Professor Lochhead, ^g it had become quite injurious by 1902, more than one-half of the crop having been destroyed in some orchards in Prince Edward County. Professor Osborn, ^h on the authority of Professor Hine, records its occurrence in north-western Ohio in 1904, and states that injured fruit comes on the market at Columbus, though perhaps from outside of the State. Doctor Chittenden ⁱ notes that the apple maggot was unusually injurious in Ohio in 1903. By 1905 the insect had extended its range in Canada, as shown by the records of Doctor Fletcher ^j of its occurrence at Como and St. Hilaire, Quebec. The apple maggot is recorded from Minnesota by Professor Washburn, ^k and the records of the Bureau of Entomology show the additional localities of Dyberry, Pa., and Douglas, Mich.

Numerous records of this Bureau, as well as published accounts, show that the insect is generally distributed throughout the greater part of the New England States, and that it is a very destructive

^a Rept. Ent. U. S. Dept. Agric., 1881-82, p. 196.

^b Rept. Mich. Hort. Soc., 1884, p. 200.

^c Second Report N. Y. State Ent., p. 121 (1885).

^d Ann. Rept. Maine State Coll. Agr. Exp. Sta., 1889, Pt. III, pp. 190-241.

^e Insect Life, VII, p. 279.

^f Rept. Ent. and Bot. Exp. Farms Canada for 1896, p. 257 (1897).

^g 33rd Ann. Rept. Ent. Soc. Ont., p. 67, 1902 (1903).

^h Bul. 46, Div. Ent. U. S. Dept. Agric., p. 88 (1904).

ⁱ Yearbook, U. S. Dept. Agric. for 1903, p. 563.

^j Rept. Ent. and Bot. Exp. Farms of Canada for 1904, p. 238 (1905).

^k Bul. 93, Minn. Agric. Exp. Sta., p. 118 (1905).

enemy to apples. The flies do not spread rapidly, and hence individual orchards or certain varieties of apples may suffer severely, while those adjoining may be little injured. Although the pest was bred from haws, in 1867, in Illinois, there has been but one record of its infesting apples in that State.^a

FOOD PLANTS.

The natural food of the apple maggot is wild haw (*Cratægus*), and probably several species are infested. It was bred from haws by Walsh in Illinois, by Cook in Illinois and Wisconsin, and by Comstock at Washington, D. C. Despite its supposed general occurrence in the fruit of this plant, no further records of breeding from haws have been found, and Professor Harvey states that it was not found in haws in Maine. During the past three years the Bureau of Entomology has collected or received fruit of *Cratægus* spp. from various parts of the country, but has not observed it to be infested with the apple maggot in any instance, and it appears quite doubtful if the distribution of the species is as general as is that of its native food plants.

The early statements of the probable feeding of this species on crab-apple appear not to have been based on actual observations, and aside from Riley's record of its occurrence on crabs,^b no definite data have been presented to show that it infests this fruit. Professor Harvey thought it improbable that this fruit would be used, for the reason that it is quite green and hard during the period of flight and oviposition of the flies. The insect was found infesting plums and late cherries in northern Michigan, by Professor Cook,^c in 1889, though no additional records of its occurrence in these fruits have been seen.

Of apples, sweet and subacid summer varieties are worst attacked, but fall and winter sorts are also infested, including distinctly acid varieties. Professor Harvey has prepared a list of apples showing their relative degree of infestation as observed by him in Maine during his careful study of the apple maggot.^d

^a Cordley, Orchard and Garden, 1889, p. 192.

^b Am. Agric., 1872, p. 263.

^c Second Ann. Rept. Mich. Agric. Exp. Sta., p. 153.

^d Loc. cit.

Varieties of apples known to be affected by Rhagoletis (Trypeta) pomonella.^a

Variety.	Flavor.			Time of maturity.	Remarks.
	Sweet.	Sub-acid.	Acid.		
Alexander			+	Autumn	Sparsingly infested.
Bullock (Am. Golden Russet)				Winter	Do.
Bailey Sweet	+			do	Do.
Baldwin			+	do	Do.
Benoni		+		Autumn	Badly infested.
Bough	+			Summer	Do.
Canada Baldwin			+	Winter	Sparsingly infested.
Catshead		+		Autumn	Do.
Chenango		+		do	Badly infested.
Colvert		+		do	Sparsingly infested.
Danvers	+			Winter	Do.
Dayton		+		do	Do.
Derby Pippin		+		do	Do.
Diana		+		Autumn	Do.
Early Harvest		+			Badly infested.
Esopus (Esopus Spitzenburg)		+		Winter	Do.
Fall Jenning		+		Autumn	Do.
Fall Pippin		+		do	Sparsingly infested.
Fameuse		+		Winter	Do.
Franklin Sweet	+			Autumn	Badly infested.
Garden Royal		+		do	Do.
Golden Ball		+		Winter	Sparsingly infested.
Golden Russet		+		do	Do.
Gravenstein		+		do	Badly infested.
Grimes		+		do	Sparsingly infested.
Hightop Sweet	+			Autumn	Badly infested.
Hubbardston		+		Winter	Sparsingly infested.
Hurlbut		+		Autumn	Badly infested.
Irish Peach		+		do	Sparsingly infested.
Jewett Red		+		Winter	Badly infested.
King Sweet	+			Summer	Do.
Lady Sweet	+			Winter	Sparsingly infested.
Maiden Blush	+			Autumn	Do.
Mexico	+			do	Do.
Mother		+		Winter	Badly infested.
Munson	+			Summer	Do.
New York Sweet	+			do	Do.
Northern Spy		+		Winter	Do.
Oldenburg (Duchess)			+	Autumn	Sparsingly infested.
Paradise Sweet	+			Winter	Badly infested.
Pearmain (?)		+		do	Do.
Pewaukee (?)		+		do	Sparsingly infested.
Porter		+		Autumn	Badly infested.
Pound Sweet	+			Winter	Sparsingly infested.
Primate		+		Summer	Do.
Pumpkin Sweet	+			Autumn	Badly infested.
Ramsdell	+			Winter	Sparsingly infested.
Red Astrachan		+		Summer	Badly infested.
Rhode Island Greening			+	Winter	Sparsingly infested.
Ribston				do	Do.
Rolfe		+		do	Do.
Russell		+			Badly infested.
Snow		+		Autumn	Do.
Somerset		+		do	Sparsingly infested.
Sops of Wine		+		Summer	Badly infested.
Tetofski	+			do	Do.
Tolman	+			Winter	Do.
Tompkins King		+		do	Sparsingly infested.
Twenty Ounce		+		Autumn	
Wagener		+		Winter	
Wealthv		+		do	Badly infested.
Westfield (Seek-no-further)		+		do	
Williams		+		Summer	Do.
Winthrop Greening			+	Autumn	Do.
Yellow Bellflower		+		Winter	Do.

^a Names of varieties of apples have been corrected to agree with those given in "Nomenclature of the Apple," by W. H. Ragan. Bul. 56, Bur. Plant Industry, U. S. Dept. Agric. (1905).

The susceptibility to injury of the respective varieties mentioned, as observed in Maine, would not necessarily be true for other regions, but the list will serve to show that all classes of fruit are subject to

attack. As a general statement, it may be said that the insect will be most destructive to summer and fall varieties, or to those varieties which are ripe or are approaching maturity during the period of principal activity of the flies.

HOW THE INSECT SPREADS.

It is not known whether the apple maggot has spread from the New England States, where its injuries were first noticed, to the several localities where its presence has been observed—as in Ohio, Wisconsin, Michigan, North Carolina, etc.—or whether the insect, already present on haws, simply turned its attention to apples. The former view, however, appears the more probable, and its spread would have been readily brought about by the introduction of infested apples. In regions where the insect occurs in apples, a considerable amount of infested fruit will be barreled, the larvæ later deserting the fruit and forming puparia on the bottom of the barrel. In the ordinary course of commerce the insect would thus be introduced into new localities, often quite remote. In view of the extent of apple production in the territory which has long been infested with this species (i. e., the New England States), and the consequent almost certain dissemination of the apple maggot to various parts of the country, it is cause for much surprise that the insect is not much more generally and widely established as an apple pest. It is very probable that the insect has been introduced into most of the apple-growing regions in the United States and also into those of Europe and the Colonies, but for some reason has not established itself. Thus the insect has been frequently found in apples on the markets in Washington, D. C., though there is no evidence to indicate that it has become established in orchards in that vicinity.

When once established in an orchard, its spread fortunately is usually very slow. It may confine its attack to a single tree, for two or three years, before spreading to adjacent trees of the same or other varieties equally subject to attack; and varieties seriously infested in one orchard may be exempt in another. The slowness of its spread from tree to tree and from one orchard to another has been commented upon by numerous workers.

The flies in their habits are exceedingly local, apparently confining their attention to the trees upon which the previous generation developed—in marked distinction to the spreading habits of many other insects. This habit is a very fortunate one for the fruit grower, and is of much practical importance in control, permitting great reduction and possible extermination of the pests when infestation is limited to but a few trees, and especially in localities but recently invaded.

DESCRIPTION.

Egg.—The eggs of the apple maggot are quite small, varying from 0.8 to 0.9 mm. in length by 0.2 to 0.25 mm. in width, fusiform, and light yellow in color as taken from the fruit. A short, broad pedicel, about one-twentieth the length of the egg, is found at the broader end, which end is darker and pitted with irregular hexagonal cells with raised lacerated borders for about one-fourth the length of the egg. (See fig. 2, *a*.)

Larva.—The larva (fig. 1, *b*) is footless, and when full grown is from 7 to 8 mm. long, with a width of from 1.75 to 2 mm., yellowish-

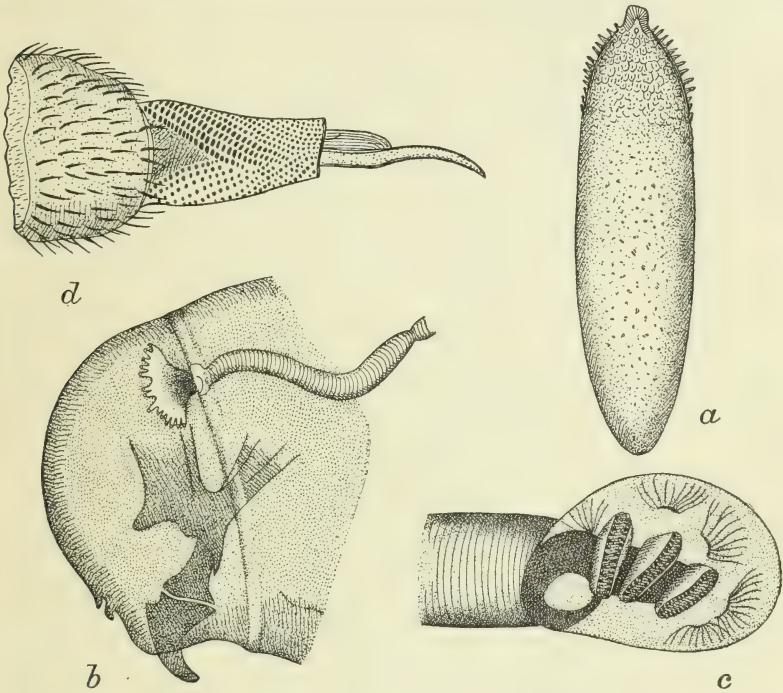


FIG. 2.—*Rhagoletis pomonella*: *a*, Egg; *b*, head of larva, showing chitinous hooks and framework within the head, and funnel-shaped spiracle; *c*, caudal spiracle; *d*, ovipositor, with which eggs are placed beneath skin of apple. All greatly enlarged. (*b*, *c*, After Comstock; *a*, *d*, after Harvey.)

white in color, at times tinged with greenish. The body is composed of 14 segments, widest across the ninth, tenth, and eleventh, and sloping gradually backward, and more rapidly toward the head end. The caudal end is truncate, and on the lower portion of the anterior end (first segment) is a pair of black, curved, parallel hooks, attached to a chitinous framework within the head, the hooks being used to rasp the pulp in the liberation of juice for food. A pair of spiracles occurs on the dorsal surface on each side at the juncture of the first

and second segments (fig. 2, *b*) and a pair on the sloping surface of the caudal segment. The spiracles on the cephalic end have funnel-shaped mouths, the funnel being bordered with a double row of about 20 projections. The caudal spiracles each show 3 transverse slit-like openings and 4 groups of bristles. (See fig. 2, *c*.)

Pupa.—The pupa is a small, barrel-shaped structure, pale yellowish-brown in color, measuring about 4.2 to 5.2 mm. in length, with a width of from 2 to 2.6 mm. The larva in pupating does not shed its skin, but simply contracts, assuming an oval form, causing the cephalic spiracles to project in front as tubercles. Although the caudal end also shrinks, the spiracles are still visible, as are also the body segments of the larva. The true pupa is formed within the larval skin. (See fig. 1, *d*.)

Adult.—The parent of the apple maggot is a two-winged fly (fig. 1, *a*), somewhat smaller than the house fly, of a general black color, with yellowish head and legs, greenish eyes, and dark feet. In the male there are 3, and in the female 4 white bands across the abdomen. Across the wings of both sexes are 4 black bands as shown in the figure. The females are from 5 to 6 mm. in length, with a spread of wings of about 12.15 mm. The males are somewhat smaller.

LIFE HISTORY AND HABITS.^a

There is but one generation of the apple maggot each year, though the occurrence of maggots in the fruit during the summer and autumn, due to the great irregularity in time of appearance of the flies, is calculated to mislead those not familiar with the insect's life history. The time and appearance of the adults is thought to be influenced by the date of the ripening of the fruit which they infested the previous season, though this supposition has not been established. During an ordinary season in Maine, the flies will begin to appear and will be ovipositing about July 1, and earlier in the States to the south. By the middle of July, in Rhode Island, during an average season, as stated by Profs. F. W. Card and A. E. Stene, early varieties subject to attack will show many of the egg punctures of the females.

Flies have lived in confinement for three weeks, and out of doors the period is doubtless somewhat longer. The female makes punctures through the skin of the apple by means of her sharp ovipositor (fig. 2, *d*), inserting the eggs singly into the flesh in a vertical position. Oviposition may occur on any part of the fruit, though mostly on the side and especially on the paler portions, where the apple has

^a The apple maggot was carefully investigated in Maine by the late Professor Harvey, and his Report (l. c.) has been largely the basis of the present article.

been protected from the sun by the foliage. An individual female is capable of producing from 300 to 400 eggs, egg laying continuing throughout her life. About one-half minute is occupied in the act of depositing a single egg, and the characteristic brownish speck left by the ovipositor can, upon close examination, be detected by the unaided eye, and resembles the brownish rusty spots occurring normally on some varieties. These egg punctures may be best observed, however, with a hand lens, and are then seen to be oblong or circular holes, with the surrounding border brownish and somewhat shrunk. In four or five days, under favorable conditions, the egg hatches and the minute footless maggot begins to feed on the pulp of the fruit. Although the larva is without true opposable jaws, it is provided with two hooks on the head above the mouth by which the pulp is rasped loose, the larva drawing into the mouth the juices thus liberated. The pulp which is not eaten soon turns brown and renders the burrows through the flesh more readily visible. The larva, in its feeding, channels here and there through the flesh, sometimes burrowing for a distance just under the skin, the brownish trail in light-skinned varieties appearing as a linear bruise.

The rate of development of the larvæ conforms to that of the fruit, and the larvæ do not mature until the fruit is ripe. Early appearing flies attack the summer varieties, and those appearing later infest fall and winter sorts. Their development is checked by cold, and they are apparently able to exist for a considerable time in a practically stationary condition until the maturity of the fruit permits of their further growth to maturity.

Apples at gathering time may show no exterior indications of infestation, yet when cut open will be found thoroughly burrowed and honeycombed by the larvæ; or the apparently sound mature fruit may be so infested with the small, inconspicuous larvæ and eggs that it may be soon destroyed after storing. The work of a single maggot will injure the value of the fruit, though a dozen or more may often be present. Under favorable conditions of temperature and in ripening fruit, the maggots will become full grown in four or five weeks. The larvæ mature as the fruit is ripe, and leave this after it has fallen to the ground, as no exit holes have been noticed in fruit on the trees. In deserting the fruit a hole is made through the skin and the larva burrows an inch or less below the surface of the soil, or on sod land probably pupates around the roots of the grass; or sometimes the pupal stage is entered on the surface of the ground under the decayed fruit. In fruit in barrels, in storehouses, etc., the larvæ pupate on the bottom of the receptacle, and the puparia are often very numerous in such places. The insect remains in the pupal stage

until the following summer, the adult fly appearing early or late, depending apparently on whether the larvæ infested summer, fall, or winter fruit.

INSECTS WHICH MAY BE MISTAKEN FOR THE APPLE MAGGOT.

There will often be found in apples partly or wholly decayed, as from the work of the apple maggot or other causes, larvæ which might very readily be mistaken for those of the species under consideration. Principally the larvæ of two kinds of flies will thus be found, namely, the vine-loving pomace fly (*Drosophila ampelophila* Loew)—a small clear-winged, red-eyed fly—and the pretty pomace fly (*Drosophila amœna* Loew), similar to the former, but with black spots on the wings. These insects are of interest as likely to be mistaken for the apple maggot and hence the cause of needless alarm. They are of little economic importance, though undoubtedly hastening the decay of fruits.

PREVENTIVE MEASURES.

The apple maggot has proved to be an unusually troublesome insect to combat successfully. The eggs are deposited beneath the skin of the fruit, within which also the larva feeds until full grown. The pupal stage is passed just under the soil, or around the roots of grass in sod land, and the flies do not feed in a way to permit of their destruction. Spraying with arsenicals, so effective against the codling moth or apple worm, is for this pest quite useless.

The insect, however, may be attacked in two important ways. As stated, the larvæ do not leave the fruit until the latter has ripened and fallen to the ground. The prompt gathering and destruction of the windfalls, before they are deserted by the maggots, would serve to keep the insects greatly reduced, amounting to practical extermination if thoroughly carried out. This practice has long been recommended by entomologists, and comprises the most effective measure of controlling the pest at present known. Greatest benefit will come from the practice when carried out uniformly by the orchardists of a community. Allowing the wormy fruit to decay on the ground is most favorable to multiplication of the apple maggot. Orchardists having this pest to contend with should arrange to destroy the infested fruit promptly after it falls, and this may be accomplished in whatever way is most practicable under individual conditions.

Picking up the fruit by hand will often prove feasible and can be done by children, but great care is necessary that the work be done thoroughly. The gatherings should be made daily if possible, or at least every two or three days. The fruit may be fed to stock, taking

care that any excess not at the moment needed be stored in tight boxes or receptacles so that any larvæ deserting the fruit will be forced to pupate on the bottom of the container, where later they may be destroyed. When the drop fruit is not needed for the stock, it may be simply thrown into a hole or holes here and there in the orchard, to be finally covered with 2 or 3 feet of earth in the late fall after frosts have occurred, to prevent the escape of flies the following season. The work of gathering need not be begun until the first ripe windfalls of the early varieties are found, but should be kept up from this time until all the fruit has been harvested.

Orchards may often be pastured with sheep, hogs, or cattle, in a way to insure the destruction of the windfalls, and this practice is recommended as the cheapest and most satisfactory method of dealing with the apple-maggot problem. Orchards may be permanently pastured or the stock turned in daily in sufficient numbers and at times to accomplish the desired consumption of the fallen fruit. This practice will be especially useful in commercial orchards, and, where infestation from adjacent orchards is not great, will insure practically clean fruit.

Plowing and cultivation of orchards would appear to be a useful practice in the control of this pest, and these methods have been more or less recommended for some years. Careful experiments in Rhode Island on the value of such work have recently been reported by Professors Card and Stene.^a Puparia of apple maggots were placed at different depths in the soil, ranging from 1 to 6 inches, to approximate conditions resulting from plowing to bury the pupæ, but this was found to have little effect in preventing the escape of flies, and the conclusion was reached that spring plowing of orchards to turn under the pupæ was valueless, under the soil conditions which there obtained.

It is thought, however, that frequent tillage of the orchard in early summer may be unfavorable to the development of the pupæ to flies, and experiments made in 1904 by Messrs. Card and M. A. Blake^b with pupæ placed in boxes in which the soil was frequently stirred, resulted apparently in their complete destruction. More extended and conclusive experiments along these lines are urgently needed. Aside from its possible value in destroying the apple maggot, frequent tillage of orchards in late spring and early summer is desirable, especially for young trees, as favoring a better tree and fruit development.

^a Seventeenth Ann. Rept. R. I. Agr. Exp. Sta., Part II, p. 191 (1904).

^b Eighteenth Ann. Rept. R. I. Agr. Exp. Sta., Part II, p. 197 (1905).

Much infested fruit goes to market, or is stored at home for future consumption. The refuse from such fruit should always be destroyed, and the barrels and boxes in which the maggots have pupated upon leaving the fruit should be treated in such a way as to insure the destruction of the pupæ. The floor of storerooms should also be carefully swept, and the sweepings collected and burned.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *March 27, 1908.*

[Cir. 101]

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United States Department of Agriculture,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

THE ASPARAGUS BEETLES.^a

By F. H. CHITTENDEN,

Entomologist in Charge of Breeding Experiments.

INTRODUCTORY.

Asparagus was introduced into this country with the early settlers from Europe, and is credited with having been cultivated here for two hundred years before being troubled with insects.

Several species of native American insects have been observed to feed upon this plant, but none, so far as we know, has become sufficiently attached to it to cause serious injury. Few of our edible plants, in short, down to the time of the civil war have enjoyed such immunity from the ravages of insects.

In the Old World two insects, called asparagus beetles, have been known as enemies of the asparagus since early times. In the year 1862 one of these insects, the common asparagus beetle (*Crioceris asparagi* L.) was the occasion of considerable alarm on asparagus farms in Queens County, N. Y., where it threatened to destroy this, one of the most valuable crops grown on Long Island. Subsequent



FIG. 1.—Spray of asparagus, with common asparagus beetle in its different stages; asparagus tip at right, showing eggs and injury. Natural size (author's illustration).

^aOther accounts of these insects have been published in earlier years, as follows: Yearbook U. S. Dept. Agric. f. 1896 (1897), pp. 341-352; Bul. 10, Div. Ent., U. S. Dept. Agric., pp. 54-59, 1898; Bul. 66, Pt. I, Bur. Ent., U. S. Dept. Agric., pp. 5-10, 1907.

inquiry developed the fact that the species had begun its destructive work at Astoria, near New York City, in 1860, where, it is now conceded, it was introduced about 1856.^a

In 1881 another European importation was detected on asparagus near Baltimore, Md.—the twelve-spotted asparagus beetle (*Crioceris duodecimpunctata* L.), sometimes called the “red” asparagus beetle to distinguish it from the “blue” species.

THE COMMON ASPARAGUS BEETLE.

(*Crioceris asparagi* L.)

From the seat of its introduction at Astoria, N. Y., the common asparagus beetle soon spread to the asparagus farms of Queens County, N. Y., and by 1862 was reported to have occasioned the loss of over a third of the crops in certain localities, the loss being estimated at \$50,000.



FIG. 2.—Common asparagus beetle (*Crioceris asparagi*): a, Dark form of beetle; b, light form. Enlarged (author's illustration).

Injury is due to the work of both adults and larvæ upon the tender shoots, which they render unfit for market early in the season. Later they destroy by defoliation the high-grown plants, particularly seedlings, the roots of which are weakened by having their tops devoured. The larvæ are sometimes so abundant that the black molasses-like fluid which they emit from their mouths soils the hands of those engaged in bunching the stalks for market; and the eggs are sometimes laid upon the stalks in such numbers that the latter are rendered unsightly and even slippery by their presence. Larvæ, as well as beetles,

attack the tenderest portions of the plants, but the beetles gnaw with seemingly equal relish the epidermis, or rind, of the stems. The beetles are also accused of gnawing young shoots beneath the surface, causing them to become woody and crooked in growth.

In some localities it is in establishing new beds that the greatest trouble and expense are incurred. The plants must grow a year as seedlings and two more in the beds before being cut for table use, and during these three years they are constantly exposed to the attacks of this insect.

The beetle is a beautiful creature, slender and graceful in form, blue-black in color, with red thorax, and with lemon-yellow and

^a The capture of this species was recorded early in the past century in Pennsylvania—presumably near Hanover—and again in the vicinity of Chicago and Rock Island, Ill., about ten years after the discovery on Long Island; but, as the insect did not obtain a permanent foothold, but died out in these localities, these importations can not be considered introductions.

dark-blue wing covers having a reddish border. A common form about the District of Columbia is illustrated in fig. 3, *a*. Farther north the prevailing form is darker, the lighter coloring sometimes showing only as a reddish border and six small submarginal yellow spots (fig. 2, *a*). An extreme, light form not uncommon in the southern range of the insect is shown (fig. 2, *b*) for comparison. The length is a trifle less than one-fourth inch.

HISTORY OF SPREAD.

From the scene of its first colonization in Queens County, the insect migrated to the other truck-growing portions of Long Island. It soon reached southern Connecticut, and has now extended its range northward through that State and Massachusetts to the State line of New Hampshire. Southward it has traveled through New Jersey, where it was first noticed in 1868, eastern Pennsylvania, Delaware, and Maryland to southern Virginia and North Carolina.

Its distribution by natural means has been mainly by the flight of the beetles. Undoubtedly, also, the beetles have been transported from place to place by water, both up and down stream by rising and falling tide, as the fact that it has not until recently deviated far from the immediate neighborhood of the seacoast and of large water courses near the coast bears abundant testimony.

Another reason for the prevalence of this species in these localities is that asparagus was originally a maritime plant and has escaped from cultivation and grown most luxuriantly in the vicinity of bodies of water. It is well known that it is usually upon wild plants that these insects first make their appearance in new localities. There is evidence also that their dissemination may be effected by what Doctor Howard has termed a "commercial jump," either by commerce in propagating roots, among which the insects may be present either as hibernating beetles or as pupæ, or by the accidental carriage of the beetles on railroad trains or boats.

By some such artificial means the asparagus beetle had found its way to northwestern New York, between Rome and Buffalo, and to Ohio, between Cleveland and the Pennsylvania State line. During 1896 its course was traced along the Hudson River above Albany. Inquiry concerning the Ohio occurrence disclosed the fact that the plants in one locality were brought from New York. The presence of this insect in eastern Massachusetts at about the same time was in like manner probably due to direct shipments of roots from infested localities to Boston and vicinity.

It is noticeable that up to this time its inland spread, except in the neighborhood of water, had been extremely limited.

DISTRIBUTION IN 1908.

This species is present now in what is known as the Upper Austral life zone, although in certain points in New England it has located in what is considered the Transition zone. Its course up the Hudson River lies within a rather narrow strip of Upper Austral. In all probability it is destined in time to overspread the entire Upper Austral zone and to make its way to some extent into neighboring areas in which it may find conditions for its continuance.

Its distribution in Massachusetts, though wide, is local. In New Hampshire it has been recorded from Nashua and Portsmouth. It is possible that in a few years it may be able to encroach slightly upon the bordering States of Vermont, in the vicinity of the Connecticut River Valley, and Maine, near the New Hampshire seaboard. It is well established in Connecticut, occurs in Rhode Island, and is generally distributed through New Jersey, Delaware, and Maryland, and in southeastern Pennsylvania near the Delaware River. It was predicted by the writer that, although this species in 1896 was still local in New York and Ohio, we might expect within a few years to hear of its invading other portions of those States lying within the Upper Austral zone; Canada, of which there is a strip of Upper Austral bordering the northern shore of Lake Erie; and, later, Indiana, Illinois, Kentucky, and States farther west. By 1897 the species had occupied the strip bordering the southern shore of Lake Erie, being recorded from nine counties of eastern Ohio. The following year it was noticed in western Virginia. In 1898 it was reported from Benton Harbor, Mich., where, however, it had been present since 1896. By 1899 it had appeared in Canada in the Niagara River region and was accompanied by the twelve-spotted species. The insect obviously received more or less severe setbacks in succeeding years, but by 1904 the common form was observed about Toronto, Canada, and about 4 miles west of Chicago, Ill. It has now become very generally distributed in the asparagus-growing sections of New York State, having reached Glens Falls, its northernmost recorded limit in the United States. In Ohio the species has been established near Columbus since 1903, and near Cincinnati since 1905, but has not been reported from Kentucky or Indiana, although it has probably invaded the latter State.

In 1904 the occurrence of this insect at Bouldin Island, California, was reported, but the following year it could not be found. Its disappearance was attributed to the fact that the island had been flooded, causing the death of the pest. In 1906, however, the beetle was reported in abundance near Oakley, Cal.

In North Carolina the species is well established in the east-central part, including portions of Wake, Wayne, Warsaw, and Duplin coun-

ties. The species has also been reported in Wisconsin, but nothing has been learned regarding its actual distribution in that State.

HABITS AND LIFE HISTORY.

The common asparagus beetle passes the winter in the adult state under convenient shelter, such as piles of rubbish, sticks, or stones, or under the loose bark of trees and fence posts. Toward the end of April or in May, according to locality, at about the season for

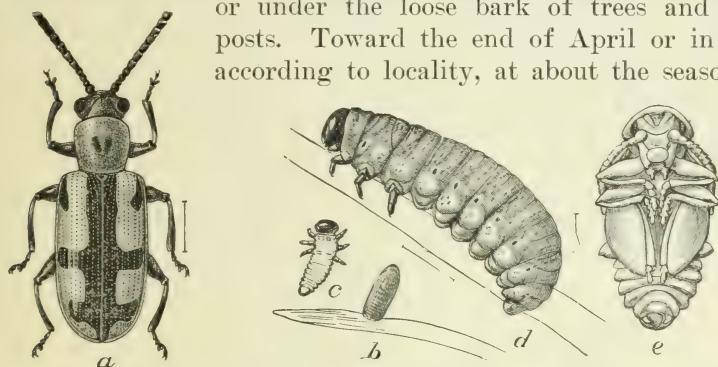


FIG. 3.—Common asparagus beetle (*Crioceris asparagi*): a, Beetle; b, egg; c, newly hatched larva; d, full-grown larva; e, pupa. All enlarged (author's illustration).

cutting the asparagus for market, the beetles issue from their hibernating quarters and lay the eggs for the first brood.

The egg is very large in proportion to the beetle, being nearly a sixteenth of an inch in length, and of the elongate-oval form illustrated at *b* (fig. 3). It is nearly three times as long as wide and of a dark-brown color. The eggs are deposited endwise upon the stem or foliage and in early spring on the developing stalks, usually in rows of 2 to 7 or more (fig. 4).

In from three to eight days the eggs hatch, the young larvæ, commonly called "grubs" or "worms," presenting the appearance indicated in fig. 3, *c*. The head of the newly hatched larva is large, black, and bead-like; its body is gray; and its three pairs of legs, black. It at once begins to feed, and is from ten days to a fortnight, according to Fitch and others, in attaining full size. When full grown the larva appears as in fig. 3, *d*. It is soft and fleshy, much wrinkled, and of a dark gray or olive color, sometimes light, but not infrequently very dark. The head is shining black, as are also the six legs. Each segment is provided with a pair of foot-like tubercles, which, with the anal proleg, assist it in crawling and in clinging to the plant. The mature larva enters the earth, and here, within a little rounded, dirt-covered cocoon which it forms, the pupa state is



FIG. 4.—Eggs of common asparagus beetle (*Crioceris asparagi*) on asparagus buds. Somewhat enlarged (original).

assumed. The pupa is yellowish in color, and its appearance is sufficiently shown by the illustration (fig. 3, *e*). In five to eight or more days the adult beetle is produced, which in due time issues from the ground.

THE LIFE CYCLE.

Of the duration of the life cycle Fitch has remarked that it is about thirty days from the time the egg is laid until the insect grows to maturity and comes out in its perfect form, but that the time will be shorter in the hottest part of the season than in the cooler days of May and June. These periods are for Long Island.

During a hot spell in midsummer the minimum period of ovulation and of the pupa stage was observed at Washington, D. C. Eggs that were laid on the 5th of August hatched on the 8th, or in three days. A larva transformed to pupa on August 4 and to adult August 9, or in five days. Allowing ten days as the minimum credited period of the larval stage, a day or two for the larva to enter the ground and form its cocoon, and two or three days more for the beetle to mature and leave the earth, the insect is again ready to attack its food plant and to continue the reproduction of its kind in about three weeks from the time that the egg is laid.

This may be fairly taken to represent the minimum midsummer life-cycle period of the species in the District of Columbia and southward. In the colder climate of New England, and elsewhere in spring and autumn weather, the development from egg to beetle will require from four to perhaps seven weeks. The hibernating beetles appear in the latitude of the District of Columbia as early as April, and beetles of a later brood have been observed in abundance in October as far north as northern Connecticut. In its northern range two and perhaps three broods are usually produced, and farther south there is a possibility of four or five generations each year.

NATURAL CHECKS.

The common asparagus beetle has very efficient natural checks in the shape of predaceous insects of many kinds, which prey upon its larvæ and assist very materially in preventing its increase. One of the most efficient of these is the spotted ladybird, *Megilla maculata* DeG. The beetle is rose-colored, with numerous black spots. The convergent ladybird (*Hippodamia convergens* Guer.), the spined soldier-bug (*Podisus maculiventris* Say), and the bordered soldier-bug (*Stiretrus anchorago* Fab., fig. 5) are also active destroyers of asparagus beetle larvæ, which they attack and kill by impaling them upon their long proboscides and sucking out their juices. Certain species of wasps and small dragon-flies also prey upon the asparagus beetle grubs. Two of the most abundant of

these are *Polistes pallipes* Lep. and *Ischnura* (*Nehalennia*) *posita* Hagen. These insects hover about the infested plants until a larva is descried, when they pounce upon it and carry it away.

Asparagus beetles are very susceptible to sudden changes of temperature, and it has been frequently noticed by Mr. C. W. Prescott, of Concord, Mass., that immense numbers of the hibernating beetles are killed in winter during severely cold spells following "open" weather, millions of their dead bodies being sometimes found under bark and in other hiding places.

The intense heat that prevailed at times during the summer of 1896, especially during the first two weeks of August, though conducive to the undue propagation of some forms of insects, had the opposite effect upon certain species that feed in the larval condition freely exposed upon the plants. In the vicinity of the District of Columbia this was particularly noticeable in the case of the larvæ of this aspara-

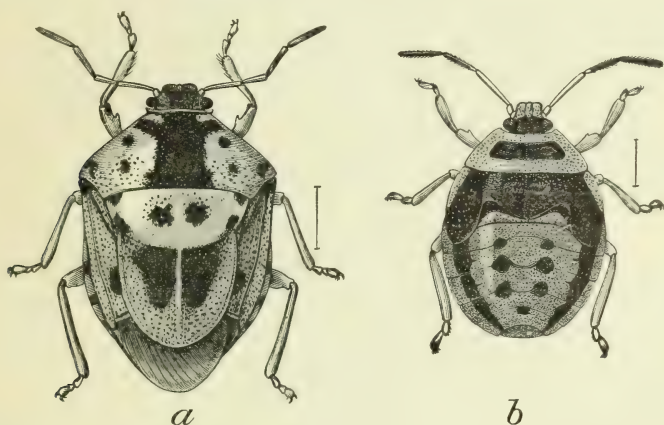


FIG. 5.—Bordered soldier-bug (*Stiretrus anchorago*): a, Adult bug; b, last stage of nymph. Both enlarged (author's illustration).

gus beetle. Its eggs also seemed to be dried up by the heat. What with the decimation caused by their natural enemies and the heat, scarcely a beetle or larva was to be found that year after the last of August.

REMEDIES.

Fortunately, the common asparagus beetle is not difficult of control, and ordinarily may be held in restraint by the simplest means.

Hand-picking is of value in small beds but must of necessity give way to more approved methods for the vast numbers of the beetles that concentrate their forces upon the large areas devoted to this crop in the suburbs of our large cities.

Chickens and ducks are efficient destroyers of asparagus beetles, and as they do no injury to the plant their services are still in requisition for this purpose at the present day.

Cultural practices.—A practice in high favor among prominent asparagus growers is to cut down all plants, including seedlings and volunteer growth, in early spring, so as to force the parent beetles to deposit their eggs upon new shoots, which are then cut every few days before the eggs have time to hatch for the first new brood.

Other measures that have been employed with advantage consist in cutting down the seed stems after the crop has been harvested, and again once or twice during the cutting season, or in permitting a portion of the shoots to grow and serve as lures for the beetles. Here these may be killed with insecticides, or the plants, after they become covered with eggs, may be cut down and burned, and other shoots allowed to grow up as decoys. The trap plants should be destroyed as often as once a week.

With concerted action on the part of growers in following out any of these last methods the insects may be held in check, at least in a region where asparagus does not grow wild in too great profusion. Where this is not practicable, insecticides must be brought into service. It is well in any case to employ insecticides after the cutting season, since if the insects are destroyed at this time their numbers will be lessened for the next year.

Lime.—One of the best remedies against the larvæ is fresh, air-slaked lime, dusted on the plants in the early morning while the dew is on. It quickly destroys all the grubs with which it comes in contact.

Pyrethrum is credited with being useful, and a mixture of soft soap, quassia decoction, and water (about equal parts of the first two to 5 of the last named) is effective against the larvæ; but these remedies hardly commend themselves for extensive use.

Arsenicals.—The arsenicals, applied dry mixed with flour, as for potato beetles, answer well; they possess the advantage of destroying beetles as well as grubs, and are of value upon plants that are not being cut for food. Some use a mixture of Paris green and air-slaked lime, or plaster, 2 pounds of the former to a barrel of the latter. To produce satisfactory results the lime or arsenical must be applied at frequent intervals, or as often as the larvæ reappear on the beds.

Arsenate of lead has given excellent results. This insecticide has come into very general use in recent years for the control of leaf-feeding beetles, such as the potato beetles and asparagus beetles. In Connecticut Dr. W. E. Britton tested it on asparagus, spraying the plants from all four sides in succession because of the slight leaf exposure as compared with most other forms of plants. Good results followed. The same amount of benefit should be accomplished with scarcely greater expense by spraying from opposite sides and repeating this

before the beetles of the last generation develop or at least in time to destroy them before they get into winter quarters. In Pennsylvania Prof. H. A. Surface made a comparative test of the value of Paris green and arsenate of lead, learning that not more than 50 per cent of the insects were killed when Paris green and lime were used, while 90 per cent were killed with arsenate of lead. In a third experiment, in which resin soap was added to make the latter insecticide adhere more closely to the plants, all of the insects were killed on 50 plants treated. In this case the arsenate of lead was used at the rate of 1 pound to 24 gallons of water, and $2\frac{1}{2}$ pounds of resin soap was added to render the mixture more adhesive.

In the North, where these experiments were made, they were begun the first of June. Arsenate of lead has been used with satisfactory results on asparagus at the rate of 1 pound in 16 gallons of water, but some additional experiments are necessary to ascertain the exact amount of the poison that can be used economically to produce the required result. In ordinary weather a second spraying of arsenate of lead with a resin soap added is desirable, especially if rainfall intervenes.

More specific information in regard to the method of preparing and applying arsenate of lead is given in Circular No. 87, which may be obtained gratis on application.

Everything considered, injury by this species is most noticeable when the beetles are working on the asparagus tips at the time they are being cut for food or market, as more fully described on page 2. It is, of course, impossible to apply arsenicals to the edible product owing to the danger of poisoning human beings. About all that can be done at this time is to cut as frequently as possible, but after the cutting season is over the arsenicals may be freely used in accordance with the directions already given.

The brushing method.—A simple and inexpensive method of killing the larvæ in hot weather is to beat or brush them from the plants with a stick so that they will drop to the bare ground. The larvæ are delicate creatures, and, as they crawl very slowly, few are able to regain shelter of the plants, but die when exposed to the heated earth. The same method is in use against the pea aphid.

THE TWELVE-SPOTTED ASPARAGUS BEETLE.

(*Crioceris duodecimpunctata* L.)

A rarer, and consequently less injurious species than the preceding is the twelve-spotted asparagus beetle. It is generally distributed in Europe, where it is apparently native and, although common, not especially destructive. Like the preceding, it lives exclusively on asparagus, and the chief damage it does is due to the

depredations of the hibernated beetles in early spring upon the young and edible asparagus shoots. Later generations attack the foliage, living, for at least a considerable portion of the larval stage, within the ripening berries.

INTRODUCTION AND SPREAD IN THE UNITED STATES.

The presence of this insect in America, as has been stated, was first discovered in 1881, and in the vicinity of Baltimore, Md. This beetle was noticed in considerable numbers from the first, showing that it had probably been introduced several years earlier. At that time it was quite local, occurring only at the mouth of the Furnace Branch of the Patapsco River at a point a few miles south of Baltimore. It was then seen only on volunteer asparagus growing on the salty margin of this river, although beds of cultivated asparagus were plentiful in the immediate vicinity. Two years later it had proved even more troublesome than the common asparagus beetle.

Assuming Baltimore to have been the original center of distribution, the twelve-spotted asparagus beetle has been traced southward through Anne Arundel and Prince George counties to the District of Columbia, where it was detected five years from the time of its first discovery.

In 1892 it was reported to have appeared in considerable numbers on asparagus stalks that had been cut down upon a farm in Carroll County, Md. The same year its appearance was announced in Gloucester County, in southern New Jersey, and the following year in Cumberland and Camden counties of the same State. To have reached these points the insect, obviously, had traversed the intervening territory in Maryland, the northern half of Delaware, and Salem County, N. J. It was also found to have reached Virginia, near Washington. In 1894 it had extended northward to Burlington County, N. J., and westward to Philadelphia County, in Pennsylvania. The same year it was detected in Queen Anne County, Md., and near Rochester, N. Y. Two years later it established itself in Charles County, Md., and had penetrated as far south in Virginia as Westmoreland County.

In May, 1896, a serious invasion was reported in Prince George County, Md., where the beetles attacked the young shoots, gnawing off the heads as soon as they showed above ground, thus entirely unfitting the crop for market.

Nearly every year since, it has been reported in new localities in the United States and Canada until now it is well distributed westward and northward. In 1898 it had become generally distributed in New Jersey "south of the shale from the Atlantic coast to the Delaware." Next year it was recorded in twelve counties in New York as far west

as Buffalo and in the following years generally throughout New York State, as also in the Niagara district in Canada.

An interesting fact in the occurrence of the asparagus beetles in the Niagara peninsula was that the two species arrived almost simultaneously and that the twelve-spotted form was the dominant one. By 1902 the latter had appeared in Connecticut, at New Haven, and later in other portions of that State.

DESCRIPTION, LIFE HISTORY, AND HABITS.

The mature beetle rivals the common species in beauty, but may be distinguished by its much broader elytra and orange-red color. Each wing cover is marked with six black dots, and the knees and a portion of the under surface of the thorax are also marked with black (fig. 6, *a*). The beetle, as it occurs on the plant when in fruit, very closely resembles at a little distance the ripening asparagus berry.

The common asparagus beetle, as is well known, dodges around a stem like a squirrel when disturbed, but the twelve-spotted form appears to trust to flight, taking wing more readily. Both species make a loud creaking sound when handled, by what is called stridulation, produced in the present species by rubbing the tip of the abdomen against the elytra.

The full-grown larva is shown at *b* (fig. 6). It measures, when extended, three-tenths of an inch (8 mm.), being of about the same proportions as the larva of the common species, but is readily separable by its orange color. The ground color is light yellowish cream with an overlay of ochraceous orange which is most pronounced on the exterior portions of the abdominal segments. The head, with the exception of the mouth-parts, is also ochraceous, the thoracic plate is prominent, divided into two parts, and is of a dark-brown color. Enlarged figures of the second abdominal segment of both species are presented at *c* and *d* (fig. 6) for comparison.

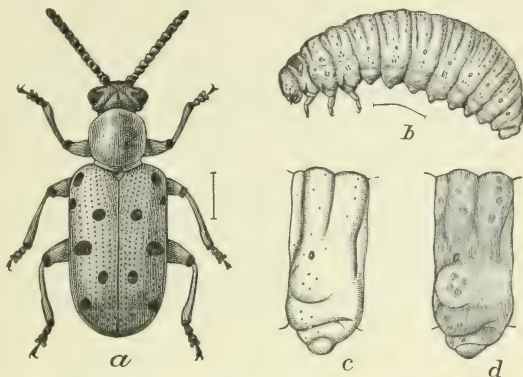


FIG. 6.—Twelve-spotted asparagus beetle (*Crioceris duodecimpunctata*): *a*, Beetle; *b*, larva; *c*, second abdominal segment of larva; *d*, same of *C. asparagi*. *a*, *b*, Enlarged; *c*, *d*, more enlarged. (Author's illustration.)



FIG. 7.—*Crioceris duodecimpunctata*: Egg, natural size, on asparagus leaves at right; same, enlarged, at left. (Author's illustration.)

In Europe, where this species is native, it is common, but not especially destructive.

The chief damage is from the work of the hibernated beetles in early spring upon the young and edible asparagus shoots. Later beetles as well as larvæ appear to feed exclusively on the berries. The eggs are deposited singly, and apparently by preference, upon old plants, toward the ends of shoots, which, lower down, bear ripening berries, and they are attached along their sides (fig. 7), instead of at one end as with the common species. Soon after the larva hatches it finds its way to an asparagus berry, enters it, and feeds upon the pulp. In due time it leaves this first berry for another one, and when full growth is attained it deserts its last larval habitation and enters the earth, where it transforms to pupa and afterwards to the beetle. The life cycle does not differ materially from that of the common species, and there is probably the same number of generations developed, or nearly as many.

REMEDIES.

The remedies are those indicated for the common asparagus beetle, with the possible exception of caustic lime and some other measures that are directed solely against the larvæ of that species, but the habit of the larva of living within the berry places it for that period beyond the reach of insecticides. The collection and destruction of the asparagus berries before ripening might be a solution of the problem, but it is questionable if recourse to this measure would be necessary, save in case of an exceptional abundance of the insect.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *April 15, 1908.*

[Cir. 102]

United States Department of Agriculture,
BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE HARLEQUIN CABBAGE BUG.

(*Murgantia histrionica* Hahn.)

By F. H. CHITTENDEN,

Entomologist in Charge of Breeding Experiments.

INTRODUCTORY.

A moderate-sized red and black plant-bug, variously known as "calico back," "fire bug," and "terrapin bug," as well as harlequin

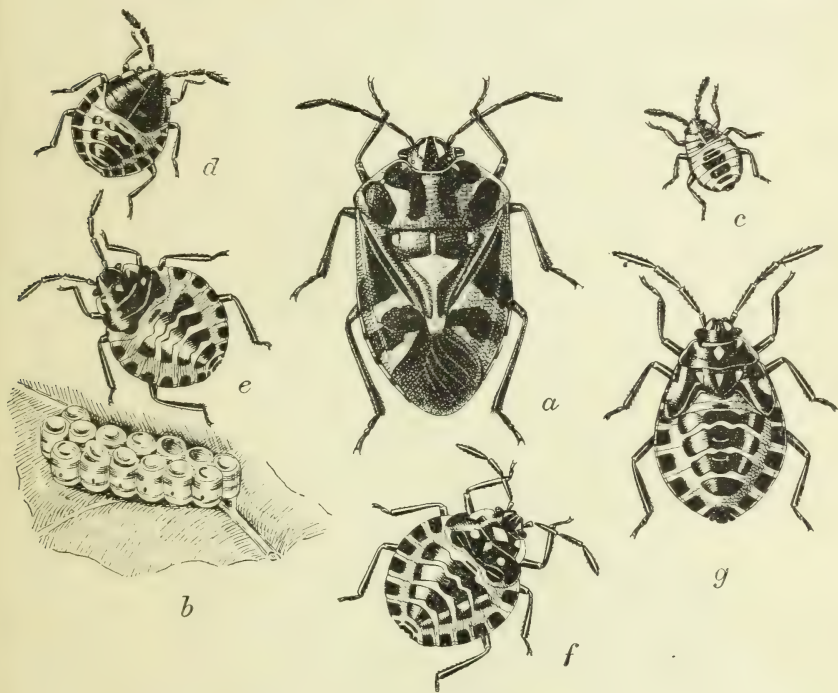


FIG. 1.—Harlequin cabbage bug (*Murgantia histrionica*): a, Adult; b, egg mass; c, first stage of nymph; d, second stage; e, third stage; f, fourth stage; g, fifth stage. All enlarged (original).

cabbage bug, is the most destructive insect enemy of cabbage and related crops in the southern part of the United States. At one time it was a serious pest northward to New Jersey and westward to Ohio

and, indeed, threatened to invade New York and New England. In recent years, however, its progress in the northern States has been checked by atmospheric conditions.

This plant-bug accomplishes its work of destruction by sucking the sap from leaves and veins of cabbage and other crucifers, the affected plants wilting, withering, and dying as if they had been swept by fire, whence the name "fire bug." It is a pest which, if permitted to propagate unmolested in seasons which favor its increase, is certain to destroy a portion if not all of the fields which it infests. A half dozen mature insects are capable of destroying a small plant in one or two days. Some years ago, when this species was abundant in the vicinity of the District of Columbia, the writer saw many large fields in Maryland and Virginia from which not a single good cabbage could be picked, and observed similar injury to horse-radish and some other crucifers.

The harlequin bug has been compared to the boll weevil as a pest in the South and to the San Jose scale as a scourge in New Jersey. Certainly it is to the cabbage grower what the other two insects are to the cotton planter and fruit raiser respectively. If growers generally, however, will undertake the methods of control, as advised in this circular, there is no reason why it should be longer destructive.

DESCRIPTIVE.

The name harlequin cabbage bug scarcely requires explanation to any one familiar with the appearance of the insect. Its gay red and black ornamentation is suggestive of the dress of the stage harlequin. In the figure of the adult (fig. 1, *a*) the dark portions illustrated are either black or dark metallic blue and the light portions are bright yellow in freshly transformed bugs and red in fully hardened individuals.

The eggs (fig. 1, *b*) are beautiful objects and remarkable for the fact that they closely imitate in miniature white barrels bound with black hoops and with black spots set in the proper place for bung-holes.

The younger stages, or nymphs, of this species bear considerable resemblance to the mature form, differing, however, in the lack of wings and in having only four joints to the antennæ, whereas the adult has five. There are five stages in all, illustrated at *c*, *d*, *e*, *f*, and *g*. In the third and fourth nymphal stages the body is hemispherical and the resemblance to a turtle or terrapin is striking.

DISTRIBUTION.

The harlequin cabbage bug is a native of Mexico and Central America—where it obviously originated—and perhaps also of the semitropical regions in Texas, Arizona, and New Mexico. It was first

recorded in injurious numbers in Texas, in Washington County, in 1864,^a and since then has traveled gradually northward, although not with uniform rapidity. Normally the species is probably tropical and has been diffused through two additional life zones, the Lower and Upper Austral. In the latter zone, however, it has not become permanently established much farther north than about the lower or warmer half. The region about Norfolk, Va., "the gateway of the South," is probably the northern limit of actual establishment in the East.

A year or two following its discovery as a pest this species had invaded Louisiana, and by 1867 was recorded from North Carolina. Its spread was most noticeable along the Atlantic seaboard and up the Mississippi River valley. In 1870 it had appeared in Missouri and Tennessee, and by 1876 had reached Delaware. In Maryland and Virginia, however, it did not attract attention until 1880. It was first recorded as injurious in New Jersey, at Woodbury, in 1892,^b and in 1894 it was seen at Jamaica and "New Lots Road," New York.^c

Westward we have office records of its occurrence in Colorado in 1882, at Pueblo and Denver, but it has never been an important pest in that region, and it was not until 1890 that it was recorded in Indiana and not till 1891 in Ohio. In the latter State it progressed steadily northward until it was checked by the same atmospheric conditions which prevailed in the Eastern States and which will be mentioned presently. In the Pacific region the species is well established in southern California, but there seems to be no published record of the time of its first appearance in that State. We received specimens from San Diego, Cal., as early as 1878. The insect is also recorded from Nevada.

The dispersion of this species in the Middle States has been traced by Mr. F. M. Webster,^d and from what has just been stated and what has been placed on record by Messrs. Webster and Howard it is very evident that it has become diffused largely by what Doctor Howard terms "commercial jumps," as in the case of insects like the asparagus beetle. This is a matter quite simple of accomplishment, as fertile egg masses can be carried long distances on the insect's food plants—for example, on the outer leaves of cabbages—by railroads and by boat. It will be noted that after the establishment of the pest in Delaware it did not attract attention farther north until twenty years later; also, that other introductions were made in different directions quite independently of each other.

^a Recorded by Gideon Lincecum, *Practical Entomologist*, Vol. I, p. 110, Aug. 21, 1866.

^b Lintner, 9th Rept. New York State Ent. f. 1892 (1893), pp. 315-317, 441.

^c Sirrine, *Bul.* 83, New York Agl. Exp. Sta. (Geneva), Dec., 1894, p. 683.

^d *Proc. Ent. Soc. Wash.*, Vol. III, pp. 288-290, 1896.

To recapitulate: This species has obviously become diffused from a central point of dispersal, Mexico, chiefly in the following three directions: (1) From Texas eastward through the Gulf States and northward along the Atlantic seaboard to Long Island; (2) from Texas northward through the Mississippi Valley and thence through the Ohio River region into Ohio; (3) from Mexico into the neighboring States and Territories, and from Lower California into southern California and Nevada.

The northward migration of the harlequin bug, although not without interruption, was apparently quite steady until recent years. Beginning with the year 1897, at which time the insect had reached its maximum as a pest in Maryland, Virginia, Delaware, and adjoining States, climatic conditions adverse to its existence developed. These consisted of sudden changes of temperature, such as cold snaps followed by warm spells and the reverse during the winter. As a result this bug, with several other forms of southern origin, was killed while hibernating and practically disappeared in the North until, at the date of writing (1908), it is scarcely, if ever, reported as injurious from the District of Columbia northward. These conditions were particularly noticeable in the winter of 1898-99.^a Small scattering colonies are, however, occasionally found in this region, chiefly on wild plants, late in the fall.

LIFE HISTORY.

In the warm and equable climate of the South where this species is at home it is more or less active throughout the year. Farther northward, however, after the first severe frosts of December it goes into hibernation in tufts of grass or under rubbish at the bases of cabbage stalks or in any convenient place. This takes place chiefly in the adult stage, although some nymphs of the last stages remain afield as late as November and December. Doubtless the nymphs succumb in time to cold, and hence fail to survive the winter.^b The first warm days of February or March, in the Gulf region, or of April, farther north, see the bugs appear abroad and beginning to feed. At first wild mustard and other cruciferous weeds are attacked and soon the insects are ready to reproduce their kind. On these wild plants the eggs are deposited, on end, generally in two more or less

^a See Bul. 22, n. s., Div. Ent., U. S. Dept. Agric., pp. 54, 55.

^b A number of adults and nymphs in the last two stages obtained from Lambert's Point, Va., October 21, 1907, were placed in a rearing cage with growing cabbage plants, grass, and similar rubbish to provide means of hibernation. For over a month or until some time in December the insects continued feeding, but when examined during the first week of March it was found that all had succumbed to the severe cold weather of February.

parallel rows cemented together in groups of about a dozen, as shown in figure 1. They are normally placed on the under side of the leaves and hatch, in warm weather, in three or four days after deposition and in five to eight days in the cooler weather of early spring. The young bugs or nymphs pass through their five stages of metamorphosis with considerable rapidity. It has been stated that the life cycle could be completed in warm weather in about two weeks, but this is obviously an exaggeration, as it requires four or five weeks for the completion of the cycle in related insects.

The life periods of this species were unknown until worked out by Mr. H. O. Marsh, of this office. Specimens (from Texas) were under observation from the first week of March until the first week of May. They were under somewhat unnatural conditions, being confined in our office room, which was maintained during this period at an average temperature of from 68° to 70° F. The first or egg stage covered 11 days. The time from the hatching of the eggs until the first molt gave the first larval instar or nymph period 7 days; the second instar required 13 days; the third, 8 days; the fourth, 14 days, while the fifth or pupal instar covered 17 days—a total of 70 days, or 10 weeks, in all, which will be not far from the maximum active period of this species. The minimum will probably fall into much lower figures, probably half of this time, or at most not more than 42 days in extremely hot midsummer weather.

When cabbage and similar plants come up the insects migrate to them. It has been surmised that owing to the rapid development of the cabbage bug in the South there is a possibility of as many as seven or eight generations each year, while in the North three or more occur. The first supposition is doubtless overdrawn, as we know of no similar insect producing so many generations annually. This is a problem for future study. It seems probable that four or five generations would be a more natural limit in the South and two, or possibly three, in the North.

FOOD PLANTS.

In the autumn after the cabbage crop has been made and in early winter, even as far north as Washington, the bugs are still afield, seeming loath to seek shelter for the cold months. At this time they cluster on cabbage stalks and sprouts and the leaves of turnip and like plants, and when the supply of crucifers has become exhausted they will attack almost any form of succulent vegetation which is most available and palatable.

On one farm the writer observed a field of 10,000 cabbage plants completely ruined, which at the time of his visit, the first week in October, had been deserted by the bugs. An adjoining field of pota-

toes was then attacked, afterwards one of eggplant, and numerous bugs in various stages were observed sucking the juices of these plants. Unripe fruit of eggplant was especially relished, and ripe pods of okra and beans were also attacked.

The list of useful plants which this species has been found to damage includes all forms of crucifers or cole crops—cabbage and related plants, kale, collards and cauliflower, turnips, radish, horse-radish, mustard, rape, and the like—and when these crops have been killed out truck crops of nearly all kinds are attacked, of which eggplant, asparagus, potatoes, tomatoes, okra, beans, and beets are most affected. Damage is sometimes done to ornamental plants such as roses, sunflowers, and chrysanthemums in flower gardens, and Mr. J. M. Rankin, while an agent of this Bureau at Chico, Cal., in October, 1905, reported that this species, after entirely destroying a half-acre plat of cabbage, attacked the other plants in the vicinity, including nursery plants of citrus, loquat, cherry and plum, squash, eggplant, "and in fact everything green." The fruit of grapes and late corn has also been attacked. The bugs are very partial to ragweed (*Ambrosia*), pigweed (*Amarantus*), wild lettuce (*Lactuca canadensis*), and lambsquarter (*Chenopodium*), congregating on all parts of these weeds but appearing to prefer the stems.

The wild food plants on which the species actually breeds include wild mustard and cresses of different kinds, shepherd's purse, peppergrass, bitter-cress, rock-cress, and practically all other plants of the mustard family (*Cruciferae*) as well as some of the closely related caper family (*Capparidaceae*).

NATURAL ENEMIES.

The comparative freedom from the attack of natural enemies which the harlequin cabbage bug enjoys is remarkable, and is due to two causes: First, to the warning type of its coloration—black and red or yellow; and, second, to its distasteful odor and flavor. This latter has been tested frequently. In the writer's experience birds that would attack most common insects would, when offered one of these bugs, either peck at it or look at it askance, or if by chance they ate a bug they did not repeat the dose.

Nevertheless the insect has one effective natural enemy, a minute parasite, *Trissolcus murgantiae* Ashm., which develops in the egg. Prof. H. A. Morgan when in Louisiana discovered that out of over a thousand eggs under observation in 1902 nearly all were killed by this useful little creature. The eggs are also attacked by *Ooencyrtus johnsoni* How. and have been parasitized artificially by *Trissolcus podisi* Ashm.

This species is also preyed upon by another bug, *Arilus cristatus* L., the wheel bug, which the writer has frequently seen attacking the young harlequins.

The influence of natural elements, particularly cold winters, has already been mentioned as a means of decimating this pest. It is well to add, however, that the writer had this species under close observation in 1899, and that as a result of sudden cold snaps, 85 per cent of the bugs in fields near Washington in that year had been killed by January 15, 1900.

METHODS OF CONTROL.

The experience of years has shown that in order to obtain the best results in the treatment of the harlequin cabbage bug preventives are necessary, as there is great difficulty in obtaining insecticides which are effective and which do not at the same time injure or kill the plants. These preventives are: (1) Clean cultural methods, especially in the fall; (2) the use of trap crops of mustard or other plants in the spring, and (3) hand methods. With strict observance of clean farming few of the insects will survive the following spring and the adoption of trap crops leaves fewer still to be destroyed by mechanical measures. In some cases all three methods should be adopted, for if they are neglected the grower will find it a most vexatious matter to control the pest in the midst of the growing season.

Clean cultural methods.—Of prime importance are clean cultural methods. The value of clean methods of farming has been recognized by nearly everyone who has had experience with this insect. The practice of leaving stalks of cabbage and other cruciferous plants in the field late in the autumn and in the early winter, or of permitting rank weeds to grow up, or, in fact, allowing any sort of débris to accumulate, serves as a means of protracting the life of this insect, as all such material either affords it food late in the season or quarters for protection against the elements during winter. It is even inadvisable to plant crucifers in the vicinity of outhouses and barns, as the bugs are apt to enter these latter for passing the winter.

Throughout the year wild plants of the mustard family, on which the insect chiefly breeds, should be carefully kept down not only in the fields but in the immediate neighborhood. A list of such plants is given on page 6.

Trap crops.—Some plants, such as cabbage, turnip, or kale, may be planted late, to be left at intervals throughout infested fields. These trap plants attract the insects in the fall, and here the latter may be killed with pure kerosene, or by mechanical methods. Where it is convenient to leave piles of rubbish until the insects are attracted to them this may be done, and the entire material, insects and all, should then be burned.

The best remedy, however, and one that should be put into operation by every cabbage grower who is troubled by this pest, consists in planting an early crop, which may be either mustard, rape, or kale, as a lure for the first-appearing insects. Radish and turnip serve a similar purpose. In the Gulf States the overwintered adults appear in February and March, and in the District of Columbia and vicinity in the latter part of April. For some reason they appear to prefer the plants that have been enumerated, and wild mustard and other crucifers, for the first deposition of their eggs. On these crops and on weeds the insects can be killed with kerosene or by the hand torch or may be collected in nets, or they may be destroyed by burning the entire trap crop when this is of no special value. Numerous reports have been received at the Department of Agriculture, and others have been recorded, of the value of trap crops as a means of controlling this pest. Some of these are worth repeating.

The first test of the trap-crop remedy was made by Lincecum (l. c.) in Texas, in 1866. Noticing that the bugs were numerous on mustard and radish in April, he handpicked them and thus protected his cabbage crop. The practical utility of this method, however, does not appear to have been recognized until considerably later. In 1891, Mr. H. E. Weed, when entomologist of the Mississippi Agricultural Experiment Station, sowed a row of mustard through the center of a 1-acre field of cabbage. In April this mustard attracted the bugs in large numbers and on it they were killed with undiluted kerosene, with the result that throughout that season the field remained free from the pest, whereas the previous year the crop was almost entirely destroyed.^a

Hand methods.—If determined efforts are made to stamp out the first generation fewer insects will remain to be dealt with and very

^a A correspondent, Mr. J. H. Hevey, Ingomar, Miss., tested the trap-crop remedy, and wrote that when the bugs made their appearance on a bed of mustard he destroyed them by "bugging," i. e., by shaking them into pans of water on which a thin film of kerosene was floating. When the mustard was removed to make room for another crop a few cabbage plants became infested, but the bugs were killed as above, and finally, after the middle of July, none was left.

One of the largest growers of cabbage in Delaware reported (Sanderson, Bul. 26, n. s., Bur. Ent., U. S. Dept. Agric., p. 67, 1900) that at one time it was impossible to raise cabbage on account of this pest, but for several years he had used kale as a trap crop, and as a result of this procedure and careful handpicking of the few bugs that strayed to the cabbage, he had been troubled very little, while his neighbors' cabbage had frequently been ruined.

In April of one year in Maryland half an acre of kale became freely infested on one side by harlequin bugs. The insects had all congregated on this side. Under the writer's direction this portion was burned, straw being used to facilitate ignition. Two weeks later not a single bug could be found in a walk about this patch, and the cabbage which was growing in several plats in the vicinity was free from injury.

few will fly from other quarters for the continuation of the species. Thus injury may be greatly curtailed if not absolutely prevented for an entire season. The large size and bright colors of the insect render it easy of detection and its sluggish nature assists in its easy capture. Mr. H. Walter McWilliams, Griffin, Ga., reports that by offering a bounty to school children for the destruction of this pest he succeeded, in March and April, 1902, in destroying the first generation in that vicinity, and estimated that this experiment saved him \$100 on his cabbage crop alone, not counting the benefit to the children.

As instance of the ease with which this insect may be hand-picked, a grower at Denton, Tex., gathered, in February of one year, 47,000 bugs. In case hand-picking has not been thoroughly done and some bugs have escaped this process and succeeded in depositing their eggs, the masses, which may be easily recognized by comparison with figure 1, *b*, should be carefully gathered and crushed.

Kerosene emulsion, according to the testimony of many who have experimented with it, is not effective against the adults and only partially effective when sprayed on the younger nymphs. Quite recently Prof. A. F. Conradi^a has found that a 10-per-cent kerosene emulsion is effective in killing the nymphs, as is also whale-oil soap, at the rate of 2 pounds to 4 gallons of water. If the insects are sprayed just after they have molted these insecticides almost invariably kill them. It is obvious that further experimentation is desirable along this line.

Other remedies.—A few words should be said of other remedies and may be prefaced with the remark that since the harlequin cabbage bug feeds exclusively by *suction* and does not chew its food, the arsenicals, hellebore, and such remedies as are useful against cabbage worms are *absolutely valueless* against the present species. Pyrethrum is not effective and is, moreover, too costly. Hot water applied at a temperature of about 130° F. to the infested cabbage plants should be tested. It is not applicable, however, to large fields on account of the difficulty of maintaining the temperature at a given point, but may be found useful in kitchen gardens.

The value of hand torches for insecticidal purposes is extremely limited. The plumbers' torch is used considerably in Texas as a means of killing this insect, but growers are apt to expect too much of this method, and to apply it to too many kinds of insects, to the ultimate detriment of their crops.

It is possible that some of the natural enemies of this species, especially southern egg parasites, might be utilized in its control; i. e., by shipping parasitized eggs from localities where they are abundant to northern regions in which they do not occur.

^a Bul. 89, Texas Agr. Exp. Sta., pp. 9-11, 1907.

SUMMARY.

The general account which has been given of this insect in preceding pages has been brought together at this time because of the practical certainty that in the natural course of events this bug will before long endeavor to reinvade territory north of its present range (in 1908), and may again become a pest for a number of years, until climatic conditions adverse to its development or increase check its northward spread.

In conclusion, it should be repeated that the systematic destruction of the insects by means of the trap-crop method described, together with a system of clean cultural practice throughout the entire season and especially in the late fall, will leave little else to be done save the gathering by hand of such insects as escape these measures or which may fly from infested to uninfested fields.

To prevent the pest from advancing farther northward than its present limits, careful watch should be kept for the first appearance of the insect, and remedies should be prompt and thorough. The importance of killing off the first or hibernated brood of bugs and their progeny can not be too strongly emphasized.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., May 4, 1908.

[Cir. 103]

O

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE COMMON RED SPIDER.*(Tetranychus bimaculatus Harvey.)^a*

By F. H. CHITTENDEN, Sc. D.,

In Charge of Truck Crop and Special Insect Investigations.

INTRODUCTORY.

One of the most troublesome of greenhouse pests is a minute, reddish, spiderlike creature, known popularly as "red spider." It does very considerable damage in flower and vegetable gardens, and in greenhouses attains its greatest destructiveness. It is particularly injurious to violets and roses, and attacks a great variety of other plants, including shade and fruit trees and some field crops. Beans, cowpeas, eggplant, cucumber, and tomato, especially when grown in hothouses, sustain much injury, while melons, squash, and berries are subject to destructive attack.

Red spiders are not true insects, in fact not even spiders, but are, more properly speaking, spinning mites. Since, however, they are almost universally known as "red spiders," this term is retained.

As the word "mite" indicates, these insects are extremely minute, and when they occur in ordinary numbers are not apt to be noticed unless the leaves are carefully scrutinized. Attention, however, is certain to be drawn to them when they become excessively numerous, as frequently happens in neglected greenhouses or out of doors during droughts in summer.

Red spiders spin threads, but do not, like true spiders, utilize them for climbing or for descending from a height. The threads spun are extremely fine and scarcely perceptible to the unaided eye, but a web

^a Until the year 1900 the common red spider, most often occurring in greenhouses, was technically designated as *Tetranychus telarius* L., a name which has been rather indiscriminately applied to all species of red spiders, both in America and abroad.

of threads is frequently so dense as to form a tissue plainly visible at a little distance. Webs are constructed upon the lower side of leaves, and attached here and there to projecting hairs, veins, or the edges of the leaves. Within the webs thus formed the mites feed in their different stages, and the eggs are laid from which the young develop.

DESCRIPTIVE.

The general appearance of this red spider as seen under a microscope is well shown in figure 1, *a*. At *b* a greatly enlarged palpus of the same species is illustrated, and *c* shows the claws, similarly enlarged.

The length of full-grown individuals, including the palpus, is about $\frac{1}{60}$ inch (0.4 to 0.6 mm), and the width about $\frac{1}{100}$ inch (0.25 to 0.30 mm), the thickness being 0.17 to 0.20 mm. The form is broadly oval, the

width greatest in the anterior third of the body, back of the eyes, where the sides are somewhat distended. The general color of the adult is reddish, usually more or less tinged with yellowish or orange, and most specimens have a dark spot on each side, due to the food contents of the body, from which the scientific name *bimaculatus* (two-spotted) has been derived.

Careful study of different individuals as they occur on garden vegetables and on horticultural and other plants growing in the field with those taken in greenhouses shows no appreciable differences. According to Mr. Nathan Banks, specimens taken in Florida on *Datura* and at Washington, D. C., on

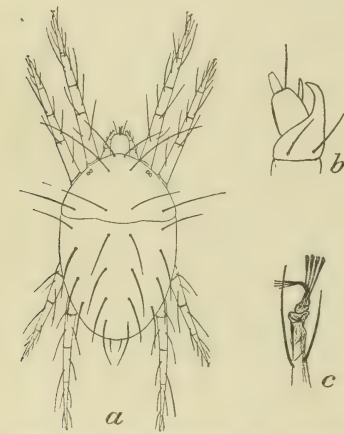


FIG. 1.—The common red spider (*Tetranychus bimaculatus*): *a*, Adult; *b*, palpus; *c*, claws. *a*, Greatly enlarged; *b*, *c*, still more enlarged. (After Banks.)

violets are red, while those from Orono, Maine, and those from the District of Columbia on squash and peach, and on rose from Idaho, are greenish with more or less dark markings.

The eggs are extremely minute, spherical, of variable diameter, glassy, and are scattered and loosely attached about the webs.

The young are somewhat similar in appearance to the adults, but differ in having only three pairs of legs, while the adult has four pairs.

DISTRIBUTION.

This red spider is well distributed throughout the eastern United States, and was identified as occurring as far west as Idaho in 1900. In 1902 it was recognized from Brighton, Wash.; in 1907 from south-

ern California; and in 1908 at Brownsville, Tex., this last locality practically assuring its occurrence in Mexico.^a

NATURE OF INJURY.

The red spider occurs in greenhouses throughout the year, and appears to be at all times destructive if permitted to propagate. Few plants are, in fact, free from its attack, and it is found in most greenhouses. When only a few mites are present the plants seldom show any external evidences of injury, but as they increase in number the leaves gradually turn paler and become yellowish and stunted, and soon the whole plant succumbs unless the proper remedies are applied. Cuttings or young rooted plants are particularly subject to serious injury, and this is especially true in the spring. At this time the mites multiply rapidly, and unless plants are carefully watched they are apt to become so badly infested that it is only with extreme difficulty that they can be restored to their normal growing condition.

The mites injure plants by suction, and when they occur in numbers, which they almost assuredly do when plants are neglected, the vitality of the plants is slowly but surely reduced by the loss of the juices, and in time all of the plants' functions are more or less deranged. In cases of severe attack, millions of red spiders can be found upon the foliage, and the webs, rarely observable at ordinary times, sometimes stretch from plant to plant, the mites passing rapidly over them and congregating in swarms.

FOOD PLANTS.

The red spider is nearly omnivorous, attacking a wide range of both glabrous and hirsute plants belonging to many families. It has been observed on plants of the following list: Among greenhouse and other ornamental plants, roses, violets, carnations or pinks, mignonette, clematis, pelargonium, abutilon, fuschia, passiflora, manettia, bouvardia, feverfew, verbena, heliotrope, salvia or sage, morning-glory, moonflower, cypress-vine, phlox, chrysanthemum, calla, Easter lily, Boston smilax, mimulus, slipper flower (*Calceolaria*), canary bird (*Tropæolum peregrinum*), thunbergia, wedding bells (*Brugmansia arborea*), castor-oil plant, *Asparagoides plumosa*, cuphea, godelia, sunflower, and aster. Of the plants listed, violets and roses are very susceptible to damage by the red spider, more especially when the plants are growing under glass.

^a If, as seems probable, *Tetranychus cucumeris* or some other species described by Boisduval (Entom. Horticole) is identical with *T. bimaculatus*, it is quite likely that this red spider is of foreign origin and introduced into the United States, which is true of a very large proportion of greenhouse and other indoor insects.

Among truck and vegetable crops, leguminous plants are greatly injured, more especially beans, including Lima beans. Cucumbers and tomatoes grown in hothouses, cantaloupes or muskmelons, watermelons, and squash are also badly damaged. Eggplant, pepper, pepino (*Solanum muricatum*), corn, cowpeas, raspberry, strawberry, beets, and celery are also subject to attack, but are not as a general rule very seriously injured.

Of field crops infested other than those which have been mentioned are hops, hemp, peanut, and the groundnut or wild bean (*Apios epios*).

Trees grown for shade and for fruit are subject to attack and considerable injury is effected at times. The list of trees that have come under observation as subject to the greatest injury includes the Kentucky coffee tree (*Gymnocladus canadensis*), the hop tree (*Ptelea trifoliata*), pecan, ornamental sassafras, arborvitæ, maple, horsechestnut, and birch.

INJURY TO TRUCK CROPS.

Every year this species is noted in considerable numbers on the underside of leaves of bean in and about the District of Columbia, frequently causing great blotches and the withering of a large portion of the leaf. When the mites occur in such abundance it necessarily causes a drain on the vitality of the plant and a decrease in the productiveness of seed-pods if not of the seeds themselves. Still, as a rule, such injury is rarely noticed until comparatively late in the season, in September and October.

Similar injury has been reported in Georgia and South Carolina to all forms of beans—snap, butter, and Lima—as well as to cowpeas. In the same States injury has been reported to a variety of other truck crops. Writing in June, one of our correspondents stated that his cucumbers looked as if a blight were on them; another wrote: "A fine garden three weeks ago now looks as if a fire had struck it."

INJURY TO TREES.

Injury by the red spider to shade and fruit trees is insignificant, as a rule, compared with that which is accomplished by leaf-feeders such as caterpillars. Sometimes, however, very considerable defoliation is caused by the attack of this species. This was very noticeable during the summer of 1906, when the foliage of various shade trees in the city of Washington was injured. Attack was first observed during the third week in July and was manifested by the leaves having turned yellow on the upper surface. The leaves on the lower branches showed the presence of numerous feeding colonies. The Kentucky coffee tree suffered most of all of our city trees. On one of these trees the leaves continued to drop throughout the remainder of July and August, but by September, partly owing to an unprecedented rainfall of three weeks' duration, the mites were less in evi-

dence and many branches from which the leaves had fallen developed new clusters of fresh leaves.

Two years later it was noticed that many of the lower branches which had suffered most from defoliation by the red spider were dead,



FIG. 2.—Kentucky coffee tree, showing partial defoliation by the red spider on lower branches; upper branches have put out new leaves. (Original.)

without doubt owing to the attack of this insect. The accompanying illustration (fig. 2) was taken after the new leaves had become well

developed. Two or three weeks before that time the lower half of the tree bore only a few leaves.

This same form of injury was repeated in 1908, the tree looking considerably worse than shown in figure 2.

NATURAL ENEMIES.

The predaceous and parasitic insect enemies of the red spider, mentioned below, were observed by the writer on the Kentucky coffee tree at Washington, D. C., during July and early August, 1906.

Scymnus punctum Lec., a very small black ladybird, was observed July 21, chiefly as a nearly full-grown larva, and was the most active natural enemy. At that time it was for the most part attached to the leaves for pupation, and a single pupa was found then and many a few days later. Nearly all the larvæ had transformed and the beetles had begun to issue by the 1st of September. An illustrated account of this species was given by J. C. Duffey in 1891.^a

Cecidomyia coccidarum Ckll. (?)—The larva of this small cecidomyiid fly was reared at Washington, where it was fairly abundant. It was secondary in importance only to the ladybird mentioned, as a destroyer of its red-spider host.

With the latter was reared a minute chalcis fly, *Aphanogmus varipes* Ashm., a species recorded as parasitic on cecidomyiids.

Chrysopa rufilabris Burm., a lacewing fly, was also reared and the larva was observed in numbers attacking the red spider.

Thrips sexmaculata Perg. has been recorded as an enemy of the red spider by Pergande^b and by Duffey.

METHODS OF CONTROL.

DIRECT REMEDIES.

Red spiders are more resistant to fumigation, either with tobacco or hydrocyanic-acid gas, than are aphides, thrips, and small forms of insects generally. Only a portion of these creatures are usually killed by the ordinary use of the gas in greenhouses—never more than 80 per cent, so far as our records go. The remainder may be stupefied for a time, but eventually recover. They are, however, extremely sensitive to sulphur, applied either dry or as a wash, or in connection with other poisons. Soap is also a good remedy.

Sulphur.—Flowers of sulphur, mixed with water at the rate of an ounce to a gallon, and sprayed over infested plants, is of great value in the eradication of this pest; or the sulphur may be combined with strong soapsuds. For the application of this spray a force pump with spraying nozzle is a necessity and the current should always be directed to the lower surface of the leaves.

Soap solutions.—Potash, fish-oil, whale-oil, and other soap solutions are valuable against the red spider, and the addition of sulphur in-

^a Trans. St. Louis Acad. Sci., Vol. V, pp. 540-542.

^b Psyche, Vol. III, p. 381, 1882.

creases their effectiveness; but these washes will injure some delicate plants. Moreover, they have no more value as insecticides than neutral soaps of the castile and Ivory type, or such as are used by physicians and surgeons.

For the red spider, as it occurs in greenhouses, particularly on plants, such as violets, that are liable to injury from sulphur, no other remedy is employed by florists generally than frequent syringing or spraying with water or with a soap solution. Neutral soaps are valuable, particularly upon cuttings affected with the red spider, and the best results have been obtained in the proportion of a 5-cent cake to 6 or 7 gallons of water. The soap is shaved with a small plane, dissolved in about a gallon of hot water, and then sufficient cold water is added to make the quantity desired. Five gallons are sufficient for the treatment of three or four thousand cuttings of violets. It is customary to allow the soap to remain on the plants two or three hours and then to syringe thoroughly with clear water, repeating this treatment two or three times, until the "spiders" and their eggs have been destroyed. Used thus, the soap has little if any deleterious effect upon most plants.

Kerosene-soap emulsion.—An emulsion may be prepared by combining 2 gallons of kerosene and one-half pound of whale-oil soap (or 1 quart of soft soap) with 1 gallon of water. The soap is dissolved in boiling water and then poured while still boiling hot (away from the fire) into the kerosene. The mixture is churned rapidly for five or ten minutes, pumping the liquid back upon itself by means of a force pump and direct-discharge nozzle throwing a strong stream. At the end of this time the mixture will have the consistency of thick cream.

Properly prepared, an emulsion will keep almost indefinitely, and should be diluted as needed for use. For the red spider the staple emulsion should be diluted with about 10 parts of water. In the preparation of kerosene emulsion a force pump is required, since if not made according to directions a perfect emulsion is not formed and there is then danger of injury to the plants or useless waste. There is danger and waste, too, if the insecticide is not applied by means of a fine nozzle in the form of a *spray*, which should be fine and mist-like. It should be sprayed only for a sufficient time to cover the plants; otherwise the liquid forms into globules and runs off. An elbow attachment for underspraying is shown in figure 3.

Lye-sulphur.—The lye-sulphur remedy was given a thorough test against the red spider in its occurrence on beans in Florida, having been applied May 28, 1908, with the result that 98 per cent of the red spiders were killed without in the least affecting the plants treated.

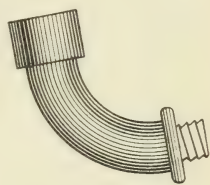


FIG. 3.—Elbow attachment for underspraying. Reduced.

This shows better results than with any of the four insecticides which were tested in that locality by Mr. H. M. Russell,^a 3 per cent more of the mites being destroyed than by the use of kerosene emulsion, which slightly injured the plants; 7 per cent more than with the use of sulphur water, and it proved to be much better than lime-sulphur, which was hardly a success as compared with the others. Lye-sulphur is prepared as follows:

Mix 20 pounds of flowers of sulphur into a paste with cold water; then add 10 pounds of pulverized caustic soda (98 per cent). The dissolving lye will boil and liquefy the sulphur. Water must be added from time to time to prevent burning, until a concentrated solution of 20 gallons is obtained. Two gallons of this is sufficient for 50 gallons of spray, giving a strength of 2 pounds of sulphur and 1 of lye to 50 gallons of water. An even stronger application can be made without danger to the foliage. This mixture can also be used in combination with other insecticides (Marlatt, Farmers' Bulletin 172).

Tobacco water.—Tobacco water is of some use for destroying the red spider, but can not be recommended for violets, owing to its tendency to weaken the foliage and induce "spot."

Water.—Spraying with water is usually practiced two or three times a week during the growing season, and by a little practice and experiment with a fine-spray nozzle or tip the operator is soon able to ascertain the proper degree of force to use. A pressure of about 25 pounds has proved most effective against this red spider. Care should be exercised to wash off the "spiders" and at the same time to avoid drenching the beds. When it is necessary to spray during winter, work should be done on a bright day, in order that the plants may dry off in a few hours. Water is also of use on shade trees and shrubs in parks.

NOZZLE AND TIP FOR GREENHOUSE USE.

Since the general adoption of spraying as a remedy for the red spider, the problem of how to apply a water or other spray so as not to drench the beds has been an important one. To accomplish this object, Dr. B. T. Galloway, Chief of the Bureau of Plant Industry, has devised a small spraying tip which answers the purpose admirably, being particularly serviceable where plants are syringed or sprayed on a large scale. The following description of the nozzle is taken from Circular 17 of the Division of Vegetable Physiology and Pathology:

The spray tip proper is attached to a brass fitting, which in turn screws onto the end of a three-quarter-inch hose. The apparatus is very effective for spraying roses, as it readily serves to keep the leaves in a thoroughly healthy condi-

^a For particulars see article by H. M. Russell in *Journal of Economic Entomology*, Vol. I, pp. 377-380, 1908.

tion, and at the same time wets the beds but little. It is also very useful for violets, as with a pressure of 35 to 40 pounds the leaves of the plant can be readily turned over and thoroughly washed without soaking the crowns and the bed. In spraying some plants, particularly violets, it has been found advantageous to use a lance 18 inches long, made of a piece of one-half-inch brass pipe. This increases the reach, and enables the operator to place the water to better advantage on plants which under ordinary conditions would be beyond arm's length. The apparatus can be made for 50 cents, and will be found a useful instrument wherever there is sufficient water pressure to insure a proper amount of force.

The illustration here presented (fig. 4) shows the general appearance of this tip and nozzle. The nozzle consists of a casting turned to the desired length and flattened at the end as figured. Through this flattened end a narrow slit is made, which should be absolutely true throughout, so that the water as it issues will be broken up into streams. It is even sometimes necessary to file the tips as they come from the factory, to secure the desired result.

TREATMENT OF TREES AND SHRUBS.

The methods of control which have been advised above are especially adapted to the treatment of greenhouses infested by the spider. All of the insecticides which have been recommended for indoor use are also applicable to trees and shrubs, the list including sulphur, which may be applied in the form of a powder by means of a powder bellows, or mixed with water as previously prescribed, or combined with lye or lime. Soap solutions, kerosene emulsion, and cold water may be used with profit. Resin wash and lime-sulphur are also used as for the orange mites or red spiders. Of these the lye-sulphur mixture is probably the best, as it is successfully used against these pests in California.

The sulphur treatment has an advantage, in that it adheres more closely to the leaves than other preparations which have been mentioned and kills young mites coming in contact with it as soon as they are hatched. Sulphur preparations are also of value in eradicating scale-insects which might be present at the same time; in fact, when the sulphur is being applied for scale-insects, red spiders or mites are likewise killed.

TREATMENT OF TRUCK AND GARDEN PLANTS.

In the treatment of truck crops infested by the red spider, little variation from the methods already advised for greenhouse work need be practiced. The same applies to ornamental flowering plants

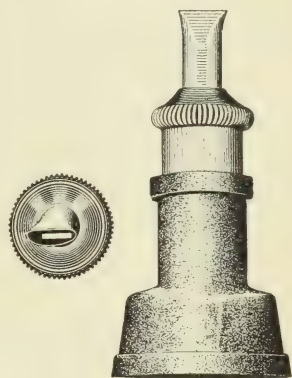


FIG. 4.—Nozzle and tip for greenhouse use. Reduced.

in gardens. Considering the great susceptibility to damage from red spider of beans, cowpeas, and other leguminous crops, and ornamental plants, it is advisable, where this mite is very destructive, as in the District of Columbia and southward, to practice rotation with plants not so subject to injury. The lye-sulphur remedy has produced the best results, as just described. Some of the remedial measures advised for the cotton red spider (*Tetranychus glomeri* Bks.), a related species occurring in the Gulf region, may be followed; indeed, the same measures are applicable to aphides and other pests which may be present on the plants at the same time.

Among cultural methods of control may be mentioned clean gardening or farming with early fall plowing, keeping down the weeds of the vicinity throughout the year, and destroying crop remnants as early as possible by burning or otherwise. Weeds growing on the edges of fields, in fence corners, and like locations should be destroyed early in the fall in order that no winter shelter may be left for the pests. Early fall plowing destroys the insects before they have an opportunity to leave the old crop plants for weeds and others.

During May, 1908, Mr. H. M. Russell, working under the writer's direction at Orlando, Fla., conducted some experiments with remedies against the red spider in its occurrence on wax beans. The results obtained, in brief, are as follows:

Kerosene-soap emulsion, 1 part stock solution to 10 parts water, killed.....	95 per cent.
Lye-sulphur, 1 pound sulphur, $\frac{1}{2}$ pound lye, to 40 gallons water, killed.....	98 per cent.
Sulphur water, 1 ounce to 1 gallon water, killed.....	91 per cent.
Lime-sulphur, 1 pound lime, 1 pound sulphur, to 25 gallons water, killed.....	68 to 85 per cent.

The results show that the red spider succumbs to any one of these four insecticides, the probabilities being that kerosene-soap emulsion, properly prepared and applied, is as satisfactory a remedy as any other applications that could be employed.

SUMMARY.

The remedies advised may be summarized as follows:

For the greenhouse and for general use, sulphur and neutral, whale-oil, and other soap solutions, kerosene-soap emulsion, and spraying with water.

For the treatment of trees and shrubs, the same as the above, with the addition of resin wash and the lime-sulphur and lye-sulphur mixtures.

For truck and garden plants, lye-sulphur wash and the same remedies as for the greenhouse, with the addition of clean gardening

or farming, early fall plowing, keeping down weeds, and crop rotation where practicable.

Finally, it should be stated that unless remedial measures be adopted and thoroughly and repeatedly applied as often as necessity demands, the red spider is almost certain to do permanent harm to delicate plants, since as soon as the plants become badly infested they seldom, if ever, fully recover.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *November 30, 1908.*

[Cir. 104]

Q

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE ROSE SLUGS.

By F. H. CHITTENDEN,

In Charge of Truck Crop and Special Insect Investigations.

Roses grown in gardens in the United States are attacked by three species of sawflies which live, in their larval stages, on the foliage, skeletonizing the leaves or cutting out holes of variable size and greatly disfiguring the plants. The larvæ, popularly known as "rose slugs," "slugworms," and "roseworms," have been classified as the American rose slug, the bristly roseworm, and the coiled or curled roseworm, respectively. For the sake of uniformity they may all be called rose slugs. The first of these, as its common name indicates, is native to America; the other two are evidently accidental introductions from Europe, as they are now common to both hemispheres. As with most other sawflies,^a they are found more abundantly in the North, but are quite troublesome as far southward as Maryland and Kansas. They practically confine their depredations to the flower garden, and roses are the only plants that are seriously damaged by them. Injury is due entirely to the larvæ, and the three species, each representing a distinct genus, differ considerably in appearance in all stages, as also in their life history and manner of work.

THE AMERICAN ROSE SLUG.

(Endelomyia rosæ Harr.)^b

The American rose slug was first identified as a pest about the year 1831, when it did damage in gardens at Cambridge, Mass. At that time the species was somewhat restricted to that locality, but later, according to Harris, who observed and studied its habits,^c it gradually spread in that vicinity and by 1840 it had become so great a nuisance that a premium of \$100 was offered for the most successful method of destroying it.

^a Hymenopterous insects of the family Tenthredinidæ.^b Synonyms: *Monostegia rosæ* and *Selandria rosæ*.^c Report Ins. of Mass. Inj. to Veget., 1841, pp. 380-382; Flint ed., pp. 525-528.

DESCRIPTIVE.

The sawfly which produces the American rose slug is a four-winged bee-like insect (fig. 1, *a*) of a deep shining black color, with translucent smoky wings having dark-brown veins and a brown spot near the middle of the edge of the forewings. The wing expanse of the female is about two-fifths of an inch and the length of the body is fully one-fifth of an inch. The male is a little smaller.

The larva or slug (*b*, figs. 1, 2) when full grown is about one-third of an inch long and sluglike, with the thoracic joints enlarged. The

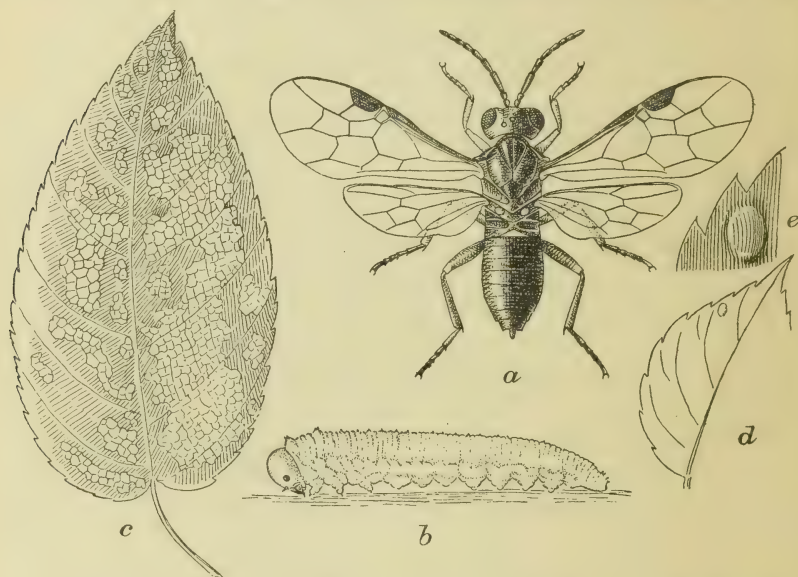


FIG. 1.—American rose slug (*Endelomyia rosæ*): *a*, Adult sawfly; *b*, mature larva; *c*, work of larvæ on rose leaf; *d*, section of rose leaf, showing location of egg near upper margin; *e*, egg in situ on bit of rose leaf. *a*, *b*, *e*, Much enlarged; *c*, less enlarged; *d*, about natural size. (Original.)

body is soft and delicate, but not gelatinous and slimy, as is the case with some sawfly larvæ—for example, the pear slug. The color is green above and yellowish on the lower surface. The head (fig. 2, *c*) is small, oval, and yellowish, and has a black spot on each side, inclosing the eye.

DISTRIBUTION.

The assertion has been made by Riley ^a that this sawfly undoubtedly originated in New England, where it fed upon wild rose. With the lapse of years, if we assume this statement to be correct, it has been disseminated by commerce into neighboring States and through the

^a American Entomologist, Vol. III, 1880, p. 115.

importation of rose bushes from eastern nurseries to western gardens. Owing to the sluggish habits of the female, its distribution by flight has undoubtedly been very slow. Its occurrence in New York, New Jersey, Ohio, Illinois, Michigan, and Missouri has been known for a number of years, and it undoubtedly occupies intervening States.

In 1904 we received reports of injuries by it in Pennsylvania, New York, Maryland, and Kansas; in that year it also appeared at Charlottesville, Va., and the following May reached the District of Columbia, where it has been quite abundant since. In 1908 it was reported injurious at Cincinnati, Ohio.



FIG. 2.—American rose slug (*Endelomyia rosæ*): a, Larvæ, natural size, upper larva at work on upper surface of leaf, lower larva at rest on under surface; b, larva, dorsal view, enlarged; c, head of larva, more enlarged. (Original.)

LIFE HISTORY.

The parent sawflies issue from the earth at varying times from about the 1st of April, or earlier in the District of Columbia, to the third week in May, or, according to Harris, until the middle of June in Massachusetts, beginning at about the time when the roses first unfold their leaves and continuing until they are in full leaf. During this period pairing takes place and eggs are deposited. The females are particularly sluggish in the cool of morning and are not often seen in flight, resting during the greater part of the day on the leaves. When disturbed they draw up their legs and fall to the ground. The males, however, are quite lively, flying from one rose bush to another and hovering around their less active partners.

The female in depositing her eggs turns a little to one side, unsheaths her delicate saw-like ovipositor, and thrusts it between the two cuticles of a leaf, depositing a single egg in each incision. An egg is shown about natural size at *d*, figure 1, and much enlarged at *e*. The egg is of circular outline, much flattened, and measures about one-twentieth of an inch in diameter. Hatching begins in from ten days to two weeks after the eggs are deposited.

The larvæ or slugs are to be found at work as early as the 1st of May in the District of Columbia, but their appearance in numbers is seldom noticed until the second or third week of that month. Observations conducted at Washington, D. C., show that the periods mentioned are subject to considerable variation. In 1905 the first sawflies of the new generation appeared June 2. Owing to the irregularity of appearance of the parent "flies," larvæ of the first generation may be found at work for a period of five or six weeks. Feeding takes place chiefly at night, and always on the upper surface of the leaves, the lower surface, ribs, and midribs remaining as a skeleton (fig. 1, *c*). The leaves are practically always skeletonized, not eaten into as in the case of the other two rose slugs, except when the larvæ are nearly grown. During the daytime the larva usually rests concealed on the under surface of a leaf (fig. 2, *a*).

Sometimes the larvæ are so abundant that not a leaf on a bush is spared, and the foliage looks as though it had been scorched by fire, and eventually drops off. The larvæ are stated to be between two and three weeks in attaining their growth. They cast their skins several times, leaving them fastened to the leaves. After the last molting they lose their greenish hue and become opaque yellowish. They then descend into the earth to a depth of an inch or more, and each constructs for final transformation a somewhat fragile oval cell or cocoon coated with particles of earth. Here the insect remains as larva until the following spring, when it transforms to pupa shortly before issuance in May.

The species is single-brooded, in which respect it resembles many other species of sawflies.^a

REMEDIES.

This rose slug and the others which will be discussed are quite easily controlled by several different methods.

Sprinkling with water.—A strong stream of water directed upon the plants from different sides by an ordinary garden hose or large

^a It is evident from Harris's account (l. c.) that in ascribing two generations to this rose slug he must also have had the bristly rose slug under observation. Miss M. E. Murtfeldt writes on this head that she has disproved Harris's statement "by repeated rearing of the insect under close observation." (41st Annual Rept. State Hort. Soc. Missouri, 1898, p. 288.)

syringe, if applied every day or two, will soon rid rosebushes of the pest. This is at the same time an excellent remedy for rose aphides or plant-lice. The insects are dislodged, fall to the ground, and are unable to return to reinfest the bushes. This remedy was tested practically by Dr. L. O. Howard many years ago.

Paris green.—Where it is possible to apply them without danger of poisoning human beings or disfiguring the plants for ornament, different poisonous preparations are useful. Of these, Paris green, either dry or in solution, arsenate of lead, and white hellebore are good remedies. Paris green is best used as a spray in the proportion of an ounce to a gallon of water. Applied dry, it is mixed with 20 parts of flour or similar diluent and puffed on the plants by means of a powder bellows or insufflator. For use in large gardens, however, the poison is employed at the rate of 1 pound to from 75 to 125 gallons of water, lime being added in about the same proportion as Paris green to prevent scorching. For properly mixing and applying this insecticide a sprayer of good quality should be used. Sprinkling with a watering pot or with a whisk broom will not answer the purpose and is, moreover, dangerous to tender foliage. The Paris green is first mixed with a small quantity of water into a fine paste before the bulk of water is added and should be churned in the sprayer or force pump until thoroughly blended. The resulting mixture, being a mechanical one, is not constant and the arsenical sinks to the bottom. The solution should therefore be constantly stirred while being applied in order that an even application may be made. In applying an arsenical spray an effort should be made to reach all of the leaves, which may be accomplished by spraying from two sides. Two or three applications will suffice for the spring generation of rose slugs. Scheele's green and some other arsenicals can be used instead of Paris green.

Arsenate of lead.—A still more valuable insecticide for such insects as rose slugs and other leaf feeders is arsenate of lead, but its use is open to the objection that it discolors the leafage, leaving a white deposit, which is not, however, permanent. It is applied in practically the same manner as Paris green and is a less poisonous arsenical, and, being sold in paste form, is used at a considerably greater strength—about 1 pound combined with 15 to 25 gallons of water or Bordeaux mixture. Being adhesive, it adheres more firmly to the leafage and is much less likely to produce scorching.^a

Hellebore.—Hellebore is used at the rate of 1 ounce to from 2 to 3 gallons of water, and kills by contact as well as by its poisonous effects

^a Additional information in regard to the preparation and use of arsenate of lead and other insecticides is given in Farmers' Bulletin 127, which may be had gratis on application to the U. S. Department of Agriculture.

when eaten by the insect. It is less poisonous to man than an arsenical, but not so effective to leaf-feeding larvæ. It may also be applied dry mixed with about double its weight, or more, of powdered plaster or cheap flour.

When not in use the receptacles containing poisons should be plainly labeled "Poison!" and placed on a high shelf or in a locker out of the reach of children. Properly applied, there is no danger, in using an arsenical on ornamental plants, of poisoning human beings, or domestic animals other than rabbits or similar pets.

Soaps and other washes.—Oily soaps, such as fish-oil or whale-oil soap, and other soaps, and tobacco water will kill these insects, but their use is open to the objection that if applied just before or at blossoming they are apt to injure the petals of delicate flowers, and whale-oil and tobacco also leave an unpleasant odor. A neutral soap, such as castile or that used by physicians and surgeons, leaves no odor.

Dry powders.—Fine, sifted road dust, where this can be readily procured, is also of value thrown upon the plants, preferably by means of a powder bellows, as it closes the breathing pores of the larvæ and thus kills them. Finely powdered lime, and buhach (Persian insect powder, or pyrethrum) are also effective.

Hand picking.—If rose slugs are picked off by hand upon their earliest appearance this will greatly reduce their numbers for the following year. In the adult or "fly" stage these insects may be easily captured by hand on cool mornings. Hand picking may be tedious, but it is effective.

Fall cultivating.—If other means that have been specified have not been utilized for the suppression of the slugs, many individuals may be destroyed by frequent cultivation of the soil between the rose plants during the late summer and autumn. This has the effect of breaking up their pupal cells and otherwise disturbing the insects so as to interfere with proper hibernation.

THE BRISTLY ROSE SLUG.

(*Cladius pectinicornis* Fourcr.)

The bristly rose slug, called also the spiny rose slug, is the principal enemy of the rose in and near the District of Columbia, not excepting the rose-chaffer. It is believed to have been brought in from Europe some time prior to 1833, since it was mentioned by Harris in his catalogue of Massachusetts insects of that date. In the early seventies it was reported from Connecticut and in after years it made its way westward and southward, doing more or less injury wherever established. Since 1880 it has done much mischief in Wash-

ington, D. C. In 1886 it was reported from Lafayette, Ind. In 1889 it was observed to be injurious at St. Charles, Mo. Soon afterwards it was recognized as a pest at St. Louis, where it attracted considerable attention.

DESCRIPTION AND DISTRIBUTION.

The adult of this species (fig. 3, *a*) differs considerably from that of the American rose slug, as will be readily seen by a comparison of the illustrations of the two forms. It is a larger insect and a member of a different genus. The wing expanse is about one-half of an inch for the female; a little shorter for the male. The ground color is black. The antennæ are rather stout and acutely pointed, and in

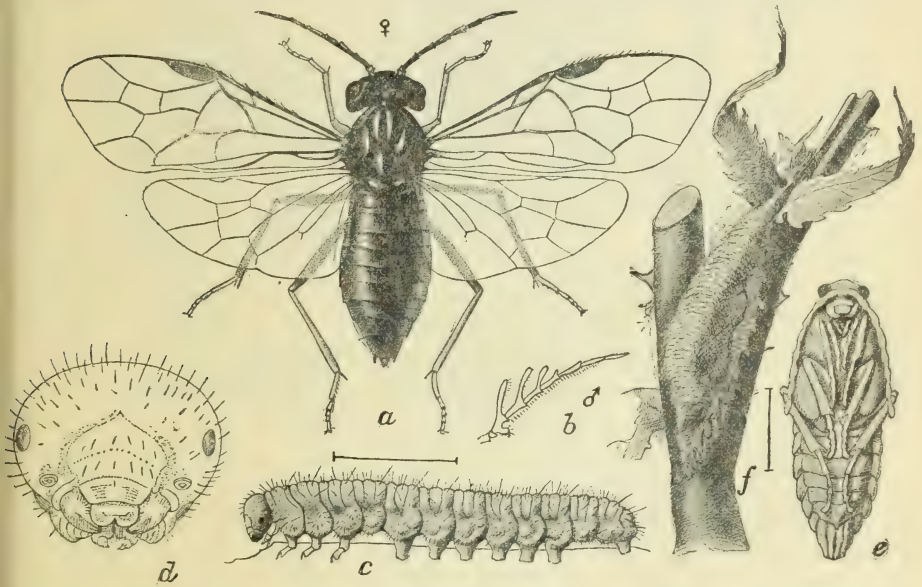


FIG. 3.—Bristly rose slug (*Cladius pectinicornis*): *a*, Adult female; *b*, antenna of male; *c*, larva; *d*, head of same; *e*, female pupa; *f*, cocoon. All enlarged. (Reengraved after Riley, except *d*, original.)

the male the proximal joints, or those nearest the head, are pectinate or comb-toothed (fig. 3, *b*), which has given rise to the specific name *pectinicornis*.

The egg (fig. 4, *a*) is white, flattened, rounded, stoutest at the anterior end, and more pointed at the opposite end. It measures about 0.8 mm. in length.

The larva or slug, shown in figure 3, *c*, and figure 4, *c*, *d*, varies from yellowish to glaucous green, and the whole surface is quite bristly, especially at the sides, a character from which this larva derives its common name and which will distinguish it from the other two that feed upon the rose. The length when full grown is a little

more than three-fifths of an inch and the diameter is between one-tenth and two-tenths of an inch.

The pupa (fig. 3, *c*) is grayish green, the thorax and end of the body are slightly yellowish, and the antennæ, wing-sheaths, and legs are white with a slight greenish tinge.^a

The distribution includes the States of Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Maryland, the District of Columbia, Indiana, Illinois, and Missouri.

It is generally distributed on the continent of Europe and occurs also in England and Scotland.

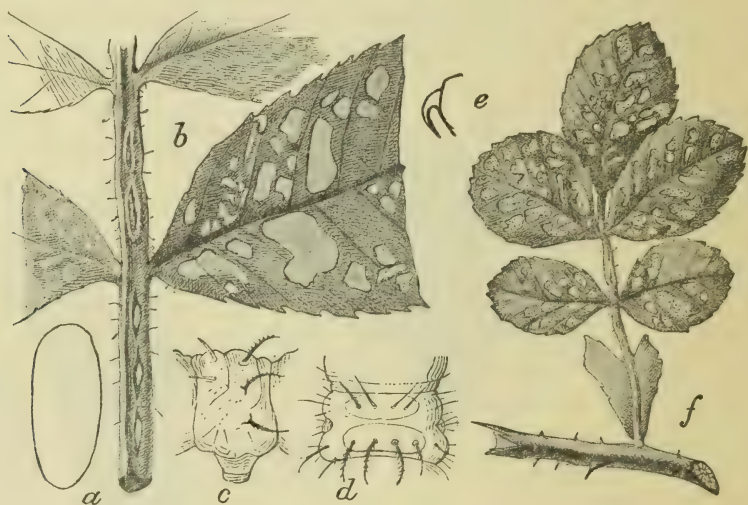


FIG. 4.—Bristly rose slug (*Cladius pectinicornis*): *a*, Egg; *b*, portion of leaf showing eggs in situ and work of young larvæ; *c*, *d*, lateral and dorsal aspects of middle segment of newly hatched larva; *e*, larval claw; *f*, rose leaf showing nature of defoliation. All except *f* enlarged. (Reengraved after Riley.)

LIFE HISTORY.

The bristly rose slug differs considerably from the preceding in its life economy. Its appearance at Washington, D. C., and at St. Louis, Mo., has been observed from the latter days of April to the third week of May, beginning about the time that the first rose leaves are put forth. Its eggs are inserted in the upper surface of the petiole of the leaf and are deposited in rows of three or more together.

The slug in its earliest stage skeletonizes the leaves, leaving whitish blotches and small holes (fig. 4, *f*), but with increased growth it eats large, irregular holes in the leaf (fig. 4, *b*), devouring the entire sub-

^a More detailed descriptions of the stages are furnished in C. V. Riley's article, *Insect Life*, Vol. V, pp. 6-11, which includes accounts of the other two species here treated.

stance, and frequently leaving nothing but the stronger ribs. While feeding, the slug rests in concealment on the lower surface of a leaf, and does not feed on the upper surface, as does the American rose slug. Upon attaining full growth it does not, like the latter, abandon the plant upon which it has fed until the final generation. Indications are that there may be three and, in some seasons in its southernmost range, perhaps four generations produced each year, larvæ occurring as early as the 1st of May and as late as the 1st of November. In northern Europe two generations are recognized.^a The larvæ of the earlier generations spin their cocoons (fig. 3, f), which are composed partly of silk and partly of a glutinous substance, upon the lower surface of the leaves, or on twigs or near-by objects, usually surrounding them with an irregular fringe. The last or autumn generation forms its cocoons among fallen leaves and other rubbish about the base of the rose bushes.

The egg period in late April and early in May has been observed in the District of Columbia to last for from seven to ten days, and the young larvæ begin feeding in the first and second weeks of May. Larvæ grow rapidly, and cocoons have been found by the middle of May. The pupal period observed was fifteen days, so that the second brood of flies may appear before the end of May. This second generation begins work about the second week in June, but during July there is a comparative cessation, presumably between the second and third broods of worms, when fresh growth is little affected.

Mr. G. Pauls, St. Louis Altenheim, St. Louis, Mo., wrote in regard to observations conducted by him on this species at St. Louis in 1904. The sawfly continued depositing eggs up to September 17. October 14 he placed larvæ in a jar; three transformed to pupæ October 17, 19, and 24 and issued March 30 to April 10 of the following year. One larva pupated October 16 and issued March 22, having passed about five months in the pupal stage. This shows considerable variation in the time of issuing indoors, and would probably be duplicated to a certain extent in the open. April 29 he observed the sawfly depositing eggs on the leaves.

NATURAL ENEMIES.

No natural enemies of this rose slug appear to have been recognized in America, but in Europe it is preyed upon by two parasites, *Acrotomus lucidulus* Grav. and *Mesochorus cimbicis* Ratz.

^a Various European authors have written on this species. One of the most accessible general articles is that by M. S. C. Snellen van Vollenhoven, translated from the Dutch by J. W. May and published in *The Entomologist*, Vol. VIII, 1875, pp. 26-29.

REMEDIES.

The same remedies advised against the American rose slug are employed against the present species, with the exception of fall cultivation, which is practically useless when applied to it, owing to the fact that the cocoons are formed upon the plants on the surface of the ground and not buried in the earth as with the preceding species. Since there are more than one generation of this slug, sprinkling with water and spraying with poisons must be repeated several times in order to produce the desired results; in short, as often as the insects reappear upon the plants, from April to October, according to locality.

THE COILED ROSE SLUG.

(*Emphytus cinctus* L.^a)

The third of the rose slugs under consideration, the coiled rose slug, is a comparatively recent importation. As with the two preceding species, it first attracted attention near Boston, Mass., but not until the year 1887.^b It is probable, however, as in the case of most European insects introduced into this country, that its importation was accomplished at a considerably earlier date. Reasoning from analogy, this insect might have been brought from the mother country on potted roses ten or twenty years earlier than the date specified, as that length of time is sometimes necessary for a foreign insect to become permanently established so as to attract attention by its injuries.

DESCRIPTION AND DISTRIBUTION.

From the two preceding species this insect may be readily separated on account of its larger size in the adult stage (fig. 5, *a*). It has nearly transparent wings, and a wide band which crosses its shining black abdomen near the middle. The body is comparatively slender, and the head longer than in the other two species. The wing expanse is about five-eighths of an inch and the length of the body about three-eighths of an inch.

The larva when mature is about three-fourths of an inch long and differs notably from the other two species here considered in being perfectly smooth. It is cylindrical and tapers very slightly toward the posterior extremity. The color is metallic green above, ornamented with small white dots, and the lower surface, including the legs, is grayish white. The head (fig. 5, *c*) is yellowish orange, with a dark brownish-black stripe down the middle. The eyes are black.

^a *Emphytus cinctipes* Nort. is recognized as a synonym.

^b J. G. Jack, Garden and Forest, Mar. 26, 1890, pp. 151-152.

The first thoracic segment is blue and the last two are gray.^a The larva habitually rests in the coiled or curled position shown in figure 5, *b*, one that is never assumed by either of the other rose slugs, and it is from this habit that it derives its English name.

In addition to Boston, it has been authentically reported from Jamaica Plain, Roxbury, and New Bedford, Mass.; portions of Maine; Allegheny, Pa.; New York, and Canada. In the Eastern Hemisphere this species ranges over the major portion of Europe, extending into Siberia.

NATURAL HISTORY.

The coiled rose slug is credited with being double-brooded, and as it extends its range southward it will probably produce a third generation, since we know of the appearance of the "worm" from May

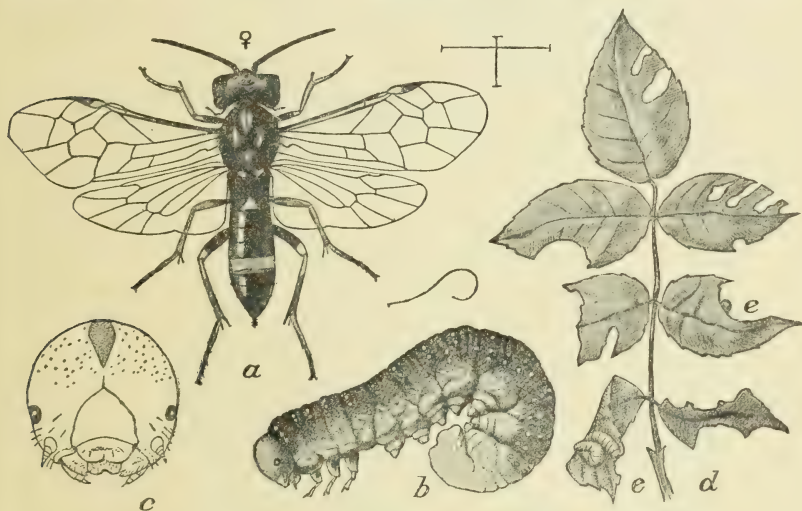


FIG. 5.—Coiled rose slug (*Emphytus cinctus*): *a*, Adult female; *b*, full-grown larva; *c*, head of same; *d*, work on plant; *e*, *e*, young larvæ at work. *d*, *e*, Natural size; *a*, *b*, enlarged; *c*, more enlarged. (Reengraved after Riley.)

to October. Eggs are deposited singly on the underside of the leaves to the observed number of from three to seven. This slug differs from the others in devouring the entire substance of a leaf, feeding along the edges with its body coiled beneath it, and when at rest remaining curled in a ball on the lower surface (see fig. 5, *e*). Upon reaching maturity the slug deserts the leaves and bores into the pith of the stems of dead rose bushes or other available plants, and here the pupal state is passed, the fall generation hibernating to emerge the following May. At Boston, Mass, the adults have also been observed in July, this indicating the first new generation.

^a A more technical description by Dr. H. G. Dyar is given in the Canadian Entomologist, Vol. XXVI, p. 186.

NATURAL ENEMIES.

A parasitic enemy of this species was reared by the writer from larvæ received from Allegheny, Pa., in 1904. It issued October 20, and proved to be a tachina fly, *Tachina rustica* Fall.

In Europe an ichneumon fly, *Cryptus emphytorum* Boie., is parasitic upon this sawfly.

REMEDIES.

The remedies are the same as for the American rose slug, subject, however, to the same changes as for the bristly rose slug.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., August 4, 1908.

[Cir. 105]

O

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE WHEAT STRAWWORM.

(*Isosoma grande* Riley.)

By F. M. WEBSTER,

In Charge of Cereal and Forage Plant Insect Investigations,

AND

GEO. I. REEVES,

Assistant in Cereal and Forage Plant Insect Investigations.^a

The wheat strawworm (fig. 1) sustains about the same relations to winter-wheat culture west of the Mississippi River that the joint worm (*Isosoma tritici* Fitch)^b does to the cultivation of this cereal east of this river. Both, when excessively abundant, occasion losses varying from slight to total. A wheat stem attacked by the jointworm may produce grain of a more or less inferior quality and less of it; but the spring attack of the wheat strawworm (fig. 5) is fatal to the plant affected, as no grain at all is produced; and while the second generation of the same has a less disastrous effect in the field, it nevertheless reduces the grade and weight of the grain.

In the Ohio Valley and south of Pennsylvania the ranges of these two insects overlap (fig. 2); both species are often to be found in the same field, the wheat strawworm, however, being less abundant and doing usually but slight injury, while the jointworm occasionally becomes a serious pest.

^a During the last two years Mr. Reeves has been engaged in the investigation of this pest in the State of Washington in cooperation with the agricultural experiment station of that State. With the exception of the statements made relative to the behavior of the pest in the Northwest, for which exclusive credit is to be given the junior author, the senior author is responsible for the circular.

^b See Circular No. 66, Bureau of Entomology, United States Department of Agriculture, 1905.

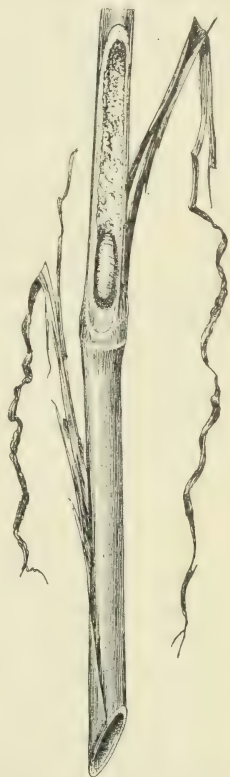


FIG. 1. Larva of *Isosoma grande* in wheat straw. (Original.)

West of the Mississippi River, throughout the winter-wheat growing territory, the jointworm, if it occurs at all, is never destructive. The wheat strawworm, on the other hand, appears to be generally distributed, at times committing very serious depredations which have, at least in some cases, been charged to the Hessian fly, as shown by the fact that some of these ravages have occurred in sections where the Hessian fly is not known to exist. Besides, while the Hessian fly is manageable with more or less difficulty, the wheat strawworm is

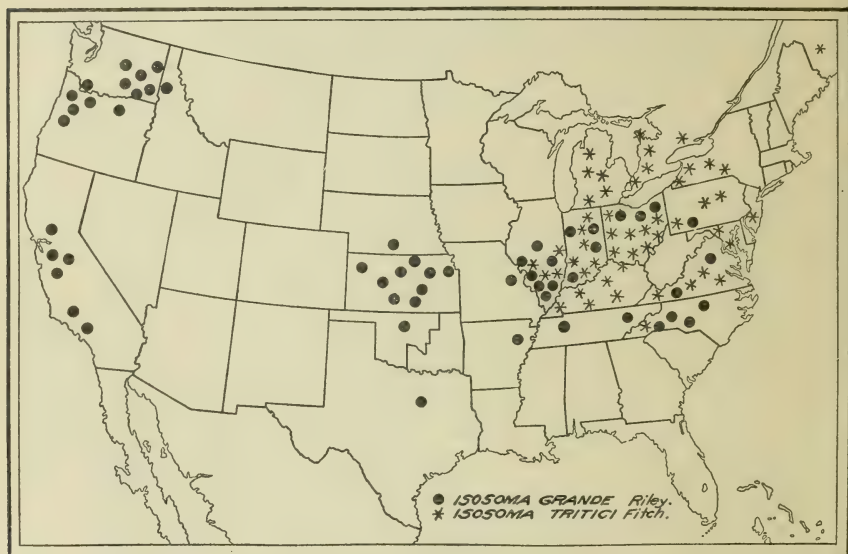


FIG. 2.—Present known distribution of *Isosoma grande* and *Isosoma tritici* in the United States. (Original.)

one of the easiest of all insect pests to control by entirely practical measures. Indeed, it need not be allowed to become a pest at all.

DESCRIPTIONS AND SEASONAL DEVELOPMENT.

There are two generations of the insect annually, the adults of the first generation (fig. 3) differing considerably in appearance from those of the second (fig. 4). To the farmer they will all look like minute or large, shining black ants, with or without wings, their legs more or less banded with yellow, and having red eyes. Individuals of the first generation emerge in April from the outstanding straws and stubble. They are very small, most of them are females, and many are wingless. The females deposit their eggs in the young wheat plants, the stems of which at this time extend but little above the surface of the ground. The egg is placed in or just below the embryonic wheat head (see fig. 6) and the larva or worm works within the

stem, usually causing a slight enlargement. When the worm is full-grown it will be found in the crown of the plant, having eaten out and totally destroyed the embryonic head, its body occupying the cavity thus formed.

The females (fig. 3) which deposit these eggs, being small and frequently wingless, are in no way fitted for traveling long distances. The larva or worm (fig. 1) is of a very light straw color, indeed almost white, with brown jaws, the form of the body being as shown in the illustration. These worms develop very rapidly and, as they feed on the most nutritious part of the plant, they become robust and larger than those found in the mature straw in late summer. In May the larvæ become full grown (fig. 5) and pass at once through a short pupal stage. (See fig. 7.) The pupæ are at first the same color as the larvæ, but later change to a shining jet black. In a few days the fully developed insects gnaw circular holes through the walls of the stem and make their way out. These adults (fig. 4) are much larger and more robust than the individuals of

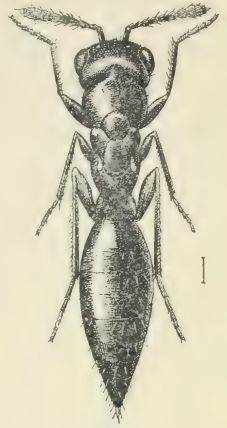


FIG. 3.—Wingless adult of the spring form of *Isosoma grande*. (Original.)

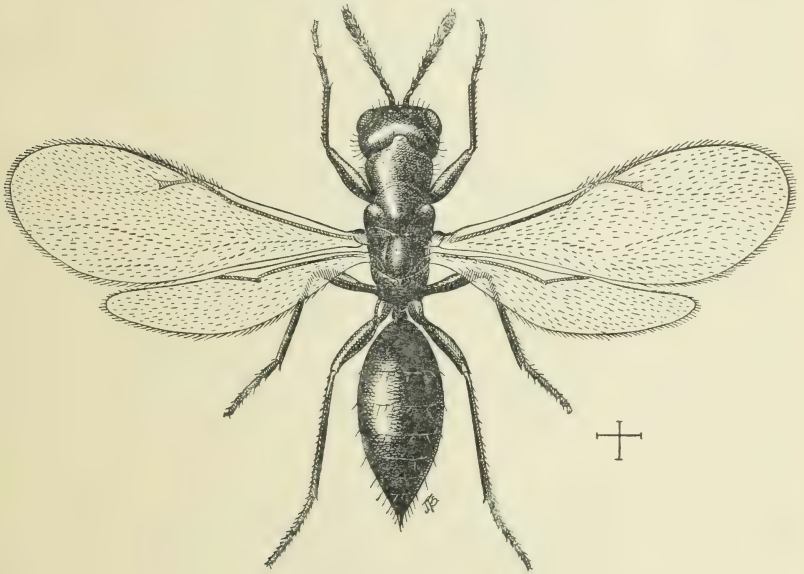


FIG. 4.—*Isosoma grande*: Adult female, summer form. (Original.)

the first generation and are provided with fully developed, serviceable wings. That they make good use of their wings, and scatter themselves about over fields adjacent to their place of development, is

shown by their occurrence in fields of grasses (in the stems of which they do not breed) situated considerable distances from wheat fields. In ovipositing, the females of this generation select the largest and most vigorous-growing stems in which to place their eggs.

The adults of the second generation deposit their eggs from early May, in Texas, up to the middle of June, in northern Indiana, or about the time the wheat is heading. Their aim at this time is to place the eggs singly in the growing stem just above the youngest and most succulent joints, which are not so covered by the enfolding leaf sheaths as to be inaccessible to them (see fig. 8). Thus it is that the stage of advancement in the growth of the wheat stems at the

time of oviposition of the summer generation of females determines whether the larvæ will be well upward in the straw, and therefore removed after harvest, or lower down and consequently left in the field in the stubble.

The method of oviposition and the point where the egg is usually inserted are shown in figure 8. The shape of the egg after being placed in the stem is also shown in the same figure. The larva forms no gall, nor does it harden the stem within which it develops. There is normally but one larva in each joint; but if several eggs have been placed between joints and produce larvæ there will be one in the center of the stem just above the joint and others in the walls just under the internal wall covering or inner epidermis. These larvæ in the walls of the straw do not, as a rule, kill the stem, but their effect is to shrink kernels, curtailing the yield by reducing the weight. The larvæ develop rapidly and reach their full growth before the straw has hardened. By October, in the Middle West, though earlier in the South, they pass

into the pupal stage, in which, as a rule, they remain until early spring, whereupon they develop to adults and gnaw their way out.

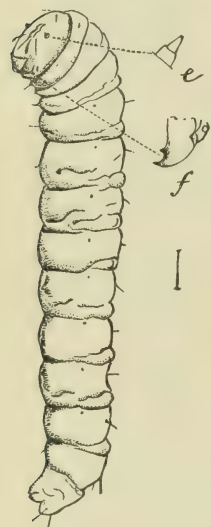


FIG. 5.—Larva of the wheat strawworm (*Isosoma grande*): e, Antenna; f, jaw. Line at right indicates natural length. (After Riley.)

HISTORY OF THE SPECIES.

In June, 1880, Mr. J. K. P. Wallace, of Andersonville, Tenn., sent wheat straws containing larvæ of this species to Dr. C. V. Riley, then Government Entomologist, with the statement that nearly every straw in his field was infested by similar larvæ and as a consequence was inclined to fall before the grain had fully ripened. It was from these straws that the types of *Isosoma tritici* Riley were secured. In October, and later on in 1881, Mr. J. G. Barlow, of Cadet, Mo., sent

Doctor Riley many infested straws, from which adults of the spring form were afterwards reared. At Carbondale, Ill., in June, 1882, Prof. G. H. French found the species infesting wheat fields, in some cases 93 per cent of the straws being affected and from one to three larvæ being found in each straw.^a

September 16, 1882, straws containing pupæ and an occasional larva were received by Doctor Riley from Mr. J. A. Starner, Dayton, Columbia County, Wash. On October 1, 1883, the senior author received infested straws from Stockton, Cal., through Professor French, and from these he was able to rear the spring form of adults during the following February. On May 8, 1884, he found adults abroad in a wheat field near Bloomington, Ill. On May 9 oviposition was observed, larvæ were found in the wheat plants May 28, and a single pupa was found on the following day, all in the same field of growing wheat. Straw taken from this same field early in the following July produced the spring form of this species the following spring—April, 1885.

At Oxford, Ind., June 6, 1884, the senior author found large winged adults of the summer form ovipositing in the stems of growing wheat, and in a small developed stem like those observed in May, about Bloomington, Ill., a living pupa was found. Straws from the Oxford field gave precisely the same form the following April as did the straw from Bloomington. The larger form, observed at Oxford June 6 and later, was also collected in fields about Bloomington a few days earlier. Larvæ of this larger form were found in wheat fields in southern Illinois in May, and the adults were observed in the same section of country in late May and early June by Prof. H. Garman, at that time assistant to Dr. S. A. Forbes.^b Doctor Riley de-

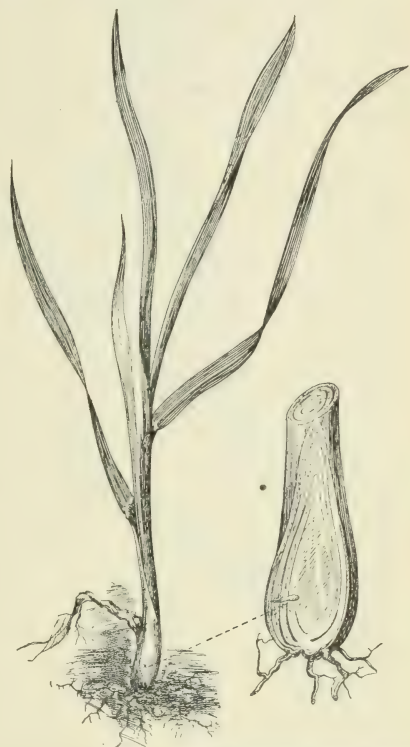


FIG. 6.—*Isosoma grande*: Showing point where female of the spring form deposits the egg in young wheat in early spring. Enlarged, showing position of egg, at right. (Original.)

^a *Prairie Farmer*, July 8, 1882.

^b Fourteenth Rep. State Ent. Ill., pp. 34-37, 1885.

scribed this larger form as a new species, giving it the name *grande*.^a During the years 1884 and 1885, however, the senior author reared Riley's *Isosoma tritici* from straws in which only his *I. grande* had oviposited and his *I. grande* from plants to which only *I. tritici* had access. As this last name had been applied by Doctor

Fitch many years earlier to another insect, the jointworm, the name *grande* must necessarily be given to both forms.

BUREAU NOTES AND OBSERVATIONS BY ASSISTANTS.

Strangely enough, one of the earliest reports of this species came from Mr. J. A. Starner, Dayton, Columbia County, Wash. Infested straws containing a few larvæ, but mostly pupæ, were received September 16, 1882, showing that even at that early date it was sufficiently abundant to attract the attention of farmers. Mr. D. W. Coquillett found it at Anaheim and Atwater, Cal., in 1885, while Mr. Albert Koebele found it during the same year at Folsom, Cal. It was also sent to the Department by Mr. J. F. Donkin, from Grayson, Cal., during the same year. In 1885 Prof. F. H. Snow reported it as doing serious injury in McPherson, Morris, Osborne, Ottawa, and Saline counties, Kans., and mentioned it as a new pest,^b and in 1891 it was prevalent in central and west-



FIG. 7.—*Isosoma grande*: Pupa of summer form in young wheat. (Original.)

ern Kansas.^c In 1886 Mr. Coquillett found it at Los Angeles, Cal. During August, 1890, infested straws from Washington State were received at the Department from Moses Bull, Pullman; J. W. Jessup, Rosalia; G. W. Dunn, Tekoa; and Milton Evans, Walla Walla.

^a Bul. Brooklyn Ent. Soc., 1884, pp. 11-12.

^b Monthly Rep. Kans. Bd. Agr., June, 1885.

^c Loc. cit., Feb., 1892.

Although there were no reports of damage in the spring, injury was sufficiently marked to attract the attention of farmers, and from these one frequently hears, even up to the present time, descriptions and reminiscences of what seems to have been the first serious outbreak of the pest in the United States.

The senior author found the species abundant but not destructive at Princeton, Ind., in 1887 and again in 1902. June 27, 1893, infested straws were sent to the Department of Agriculture by Mr. E. J. Woodville, Indiantown, Va. In 1905 the junior author found the species infesting growing wheat about Conway, Ark., April 7, the larvæ being apparently full grown; and at Petty, Tex., April 14, he found larvæ and pupæ present in great numbers, in some cases 50 per cent of the young wheat plants being infested. He also found half-grown larvæ at Concordia, Kans., April 21. During the same year the senior author found larvæ in young wheat at Lexington, N. C., April 12; and at Statesville, N. C., on the following day, he found not only larvæ in the young plants, but females of the spring form in the act of ovipositing. At Charlotte, N. C., April 14, larvæ and pupæ were found abundantly in the young wheat. On the 18th of the same month young larvæ were found in young wheat plants at Dublin, Va. Mr. W. J. Phillips found the species quite numerous in young wheat plants at Nashville, Tenn., April 20, and studied the oviposition of both forms at Richmond, Ind., from May 26 to June 27. June 16 the Bureau received infested straws from Mr. H. W. Joy, Hays, Kans. On May 24 of the following year, Mr. Phillips found the species abundant at Geneva, Ind., where the females of the summer form were just beginning to emerge from the young wheat; and the senior author observed it again at Charlotte, N. C., May 9, with indications that it had done considerable injury to young wheat. Mr. Phillips observed it during 1907 at Kingfisher, Okla., and at Beloit, Kans., on April 15; at Lenora, Kans., May 20; and at Kearney, Nebr., May 24. In all cases it was more or less abundant. June 1 of the same year Mr. C. N. Ainslie found adults of the spring form at Wellington, Kans.; from April 30 to May 7 he found the adult females of this form abroad in the fields at Sterling, Kans.; and on May 26 he found them ovipositing in wheat at Hays, Kans., and other points

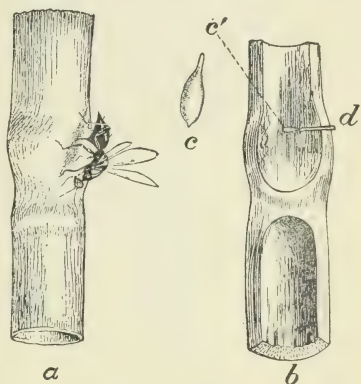


FIG. 8.—Method of oviposition of female of summer form of *Isosoma grande*: *a*, Female inserting her eggs; *b*, section of wheat stem showing egg and ovipositor; *c*, egg, greatly magnified; *c'*, egg in position in pith of wheat stem; *d*, ovipositor. (*a*, After Riley; *b*, original.)

farther west. He found them ovipositing in durum wheat at Oakley, Kans., June 3, and on the following day also in durum wheat at Colby, Kans. Again, June 8, he found them abroad in wheat fields at Manhattan, Kans. Females of the summer form were observed by Mr. E. O. G. Kelly ovipositing at Caldwell, Kans., May 14, 1908.

May 26 to 28, 1908, Mr. Ainslie found both sexes, the females ovipositing, near Chambersburg, Pa. This is the farthest east that we have any record of the existence of the species, the most eastern point of occurrence previously known being at Andover, in extreme northeastern Ohio, where the senior author found the larvæ in wheat straw, August, 1904.

As will be observed from the foregoing, the adult female emerges early in spring and deposits her eggs in the young wheat plants before the latter have made much growth. By the time wheat is beginning to show the heads within the enfolding sheath leaves, adults of the

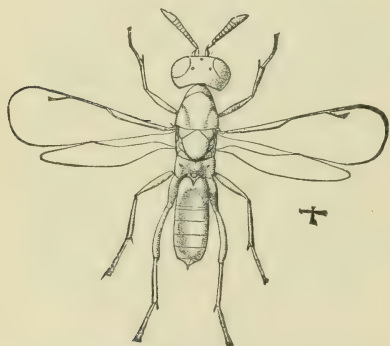


FIG. 9.—*Eupelmus allynii*: Male, much enlarged. (From Riley.)

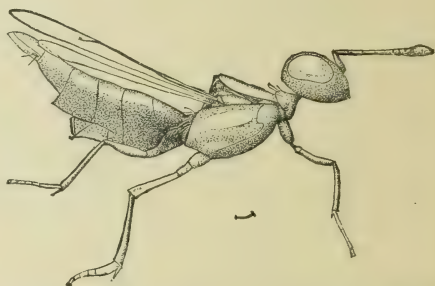


FIG. 10.—*Eupelmus allynii*: Female, much enlarged. (From Riley.)

second generation are abroad and depositing in the upper stems; the larvæ from these pass the winter as pupæ and emerge as adults early the following spring, exact dates of course varying with the latitude and other influences.

NATURAL ENEMIES.

Probably the most efficient enemy of this species is a small, slender, four-winged fly (figs. 9, 10), with a somewhat brilliant metallic body and yellow legs. It has a very slight resemblance to an *Isosoma*, and, indeed, was described by French as *Isosoma allynii*, but it is now known as *Eupelmus allynii*. A somewhat similar insect with metallic body and yellow abdomen, *Semiotellus isosomatis* Riley (fig. 11), is very efficient in destroying the larvæ in the straw. *Homoporus* (*Semiotellus*) *chalcidiphagus* Walsh (fig. 12), and beyond a doubt other chalcidids, are also instrumental in holding it in check. These

parasites are all the more efficient as they are double-brooded, developing in late summer and at once ovipositing in other larvæ.

In 1908, at Wellington, Kans., Mr. E. O. G. Kelly, beginning April 10 with the larvæ in the straw, followed the insect up to June 4, witnessing oviposition in both the spring and summer forms. Through the remainder of June and most of July he was absent, and on his return he was unable to find the larvæ in the straw, although stubble and straws perforated with holes made by the escaping parasites were found everywhere in the fields. On account of the abundance of such evidence in the fields, Mr. Kelly was convinced that the pest had been largely overcome in that locality by *Eupelmus allynii*. At Pratt, Kans., November 17, a few larvæ were found in wheat straws, with indications that parasites had been present to a limited extent, and practically the same situation was found to occur at Sedgwick, Kans., the following day. Quite significant, however, was the fact that in the vicinity of Pratt, on September 16, Mr. T. D. Urbahns found in an



FIG. 11.—*Semiotellus isosomatis*: Parasite of *Isosoma grande*. Greatly enlarged. (Original.)



FIG. 12.—*Homoporus chalcidiphagus*: Parasite of *Isosoma grande*. Greatly enlarged. (Original.)

old wheat field not a single living *Isosoma* larva, while 85 per cent of the straws gave unmistakable evidence by the holes in them that these larvæ had been present, but were destroyed by parasites.

Quite in accord with this it will be remarked that the junior author, in his discussion of the outbreak of the pest in Washington State, in 1908, does not mention parasites at all—not because he overlooked the matter, but because he reared only a single individual parasite, probably *Semiotellus isosomatis* Riley, and there was no evidence of the presence of parasites in any numbers in the section of country visited by him. This will perhaps throw some light upon the prime causes of this outbreak. Besides, it opened the way for an introduction into Washington State of the parasites affecting the pest in the East. It is as yet too soon, however, to expect definite results from these introductions.

In Indiana and the Middle West when the wheat is harvested the straw is frequently, and, in fact, almost invariably, cut off between

joints, thus leaving the larvæ, if there are such in the straws at that point, exposed to attack from predaceous insects. The larvæ of a small, slender, black and yellow carabid beetle (*Leptotrachelus dorsalis* Fab.) crawls up the stalks, descends into the stubble, and devours the *Isosoma* larvæ, but unfortunately its taste is such that it does not confine itself strictly to *Isosoma* but devours parasite as well as host. The mite *Pediculoides* (*Heteropus*) *ventricosus* (fig. 13) is also an enemy, gaining access to the larvæ precisely as do the beetle larvæ previously mentioned.

PREVENTIVE MEASURES.

There are no remedial measures, since it is impossible to alleviate or influence in any way the effect of larvæ in the infested wheat plants. As it is the larger and more vigorous plants that the females select for egg-laying purposes, no amount of enriching the soil will affect the numbers of the pest or lessen their influence. Preventive measures are, however, simple, practicable, and effective. Indeed, the wheat-straw worm is one of the very easiest of all insects to control. The diminutive size of the female that emerges in early spring renders extended migrations fatal, since during that period, when the weather is, of all seasons, the most erratic and liable to sudden and extreme changes, it tries to avoid the frequent storms by seeking protection on the underside of the leaves of the growing plants. But, most fortunate of all for the farmer, large numbers, if not indeed much the greater proportion, of these females have no wings and can only make their way from place to place by crawling.

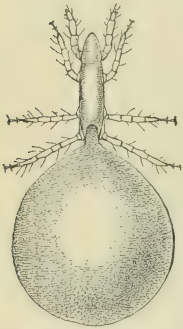


FIG. 13.—*Pediculoides ventricosus* Newp., a mite which destroys the larva. Much enlarged. (After Marlatt.)

The advantage of all of this to the farmer is shown by the fact that, where the preceding crop has been other than wheat, the injury to the young wheat plants in spring is confined to the margins, and especially where such margins border on other fields that have been devoted to wheat for a number of consecutive years. Mr. Reeves, as will be observed further on in this publication, has been able to measure the relative diminution of attack from the borders of the field inward toward the center. Similar observations had previously been made in other sections of the country. One of the earliest notes made on this species by the senior author was in June, 1884, in a field of wheat sown the previous autumn, among corn, the land bordering to the south on a stubble field. The following spring there were many wheat plants injured along the south margin of the field, but none could be found along the northern border. With the appearance of

the second generation, composed of large, vigorous females with well-developed wings, the diffusion would become comparatively general, and, therefore, the second year, if the field were to be continued in wheat, would find the infestation more nearly uniform throughout.

It is significant, too, that the pest becomes much more destructive the longer wheat is grown continuously on the same ground. As early as 1882 Prof. G. H. French observed that while 93 per cent of the straws were infested in a field where the same grain had been grown the year before, in a field where clover had been grown the previous year only about 5 per cent of the straws were infested. At Petty, Tex., April 14, 1905, the junior author found a field of wheat that had been in this grain for two consecutive years very seriously injured. There were spots several yards square where the ground was bare, and surrounding these were areas where half of the living plants were infested. At Sawyer, Kans., in an old field, Mr. Urbahns found that 85 per cent of the straws gave unmistakable evidence of having been infested. All of this points conclusively to the efficiency of a rotation of crops that will eliminate the growing of wheat two years in succession on the same land. Where for any reason this can not be done, the measure next in efficiency will be the burning of the stubble and outstanding straw during the fall or winter.

RELATIONS OF THE WHEAT STRAWWORM TO WHEAT PRODUCTION IN THE NORTHWEST.

By GEO. I. REEVES.

The wheat strawworm, by reason of its relation to both the climate and the farm methods of the most productive portion of the Pacific Northwest, is capable of great injury to wheat growers. Though its greatest inroads are made upon spring wheat, it is winter and volunteer wheat which render those inroads possible. Its work is of such nature that it passes unobserved, unless an attack of unusual severity causes the farmer to scrutinize his fields more closely than he is accustomed to do. The constant small losses occasioned by this insect and the possible destruction of the crop over considerable areas may be prevented by such measures as every good farmer employs to maintain the fertility of his soil, secure a good seed bed, retain moisture, and eradicate weeds.

The strawworm may be found wherever wheat is grown in the Columbia basin, that great and fertile plain of varying topography and climate which is inclosed by the Okanagan Highlands on the north, the Rocky Mountains on the east, the Blue Mountains on the south, and the Cascade Mountains on the west; but it is not equally destructive over all that territory. The central and western parts of this basin, except in the Goldendale and Horse Heaven districts,

are arid, producing little or no wheat, and a strip east of this, known as the dry-farming region, where the scanty rainfall makes it necessary to summer-fallow the land every second year, is by that means protected from serious injury; but the eastern zone, a strip 200 miles long, included between the dry-farming area and the upper limit of wheat culture at the elevation of 3,000 feet, affords ideal conditions for the production of small grains and also for the propagation of this insect. The climate is characterized by mild winters suitable for the growing of winter wheat—cold, wet spring weather, such as is desirable for all small grains, and hot, dry summers perfectly adapted to the maturing and harvesting of the crop. The soil is such that after more than thirty years of almost continuous production it still yields 30 to 40 bushels of wheat per acre. These conditions encourage the seeding of wheat year after year upon the same ground, and such a practice, together with the presence of winter or late volunteer wheat, supplies the requirements for the unhindered multiplication of the strawworm. Owing to the drought of summer the volunteer wheat usually does not germinate until about the same time as the fall-sown wheat, and the significance of this fact appears when we come to study the insect's life history.

This *Isosoma* passes the winter in the larval (fig. 1) or pupal (fig. 7) stage and reaches maturity early in April. It gnaws its way out of the stubble in which it has hibernated and deposits its eggs in the heart of the young plants of winter or volunteer wheat (fig. 6), which must be near the place of emergence, since this early generation is largely wingless (fig. 3), and its effective range as measured by the spread into an adjoining field is not much more than 12 feet. The food plants of the early generation may be supplied by winter wheat or by volunteer wheat not too far advanced to attract the insect. The oviposition is finished before any spring wheat is up, so that that crop suffers no attack from the first generation. The winter and volunteer wheats lend an essential aid to the perpetuation of the species.

The larva (fig. 5), when it hatches from the egg, is surrounded by the most delicate tissues of the plant and feeds upon them, destroying the young head and thus excavating a residence to accommodate its rapidly increasing size. The outer, tougher layers, which it does not attack, gradually become fleshy, stiff, and brittle, forming a hollow, bulblike swelling at the base of the plant. This enlargement is discernible from the outside of the infested plant, and its presence may be verified by squeezing the crown of the plant between the fingers, whereupon the bulb at first firmly resists pressure and then breaks open, disclosing the larva. The infested plant suffers a change in external form, which causes it to resemble wheat

injured by the Hessian fly and by *Meromyza*, but it may usually be distinguished from the former by the curly and slightly fleshy form of the blades; from the latter by the absence of the brown, threadlike central shoot, as well as the form of the blades; and from both by the presence of the crisp bulb at the crown. The lower blades are broad, dark bluish green, curly, and slightly fleshy, because they arise between the root and the point of injury and thus receive the sap that is being diverted by the larva from the main growing point of the plant. The plant, when attacked thus early at the heart, remains low, does not produce any head, and perishes when the lower blades of the plants naturally die, about the middle of June. At about the same time the adults of the second generation (fig. 4) begin to emerge from these plants and deposit eggs upon the wheat. These insects, as were those of the first generation, are nearly all females, and they also reproduce without the assistance of males, but they differ from the earlier form in being larger and in possessing wings, which enable them to attack fields at a distance from their origin. They prefer the younger plants, and as the spring wheat is small at this time, while the winter wheat is old and tough, the summer attack is concentrated upon spring wheat, if there be any in the vicinity. They attack it in much the same way that the spring generation employs upon the young winter wheat, and with the same result; the smaller plants simulate a luxuriant growth, but remain short and soon die; the larger ones may produce heads, a few inches above ground, but such heads contain no kernels. Thirty acres of spring wheat near Colfax, Wash., were completely ruined in this manner in the summer of 1907.

Since spring wheat is not so extensively grown as formerly in this region, the summer adults are often compelled to oviposit in winter wheat, and in those cases the plant is less severely injured, because it is old and tough; but the larva of the insect and the resulting adult take the same form and size whether they develop in the tender spring wheat or in the more mature winter wheat. The succulence of the former does not cause an increase in the size of the larvæ which feed upon it, nor does it produce a larger proportion of winged individuals among the adults. On the contrary, it seems that austere and unfavorable circumstances tend to increase the number of winged adults, as a large percentage of those reared from stubble collected at Goldendale, St. Germain, and Waterville, Wash., in the arid district, have wings. The egg is placed in a tender joint near the head (fig. 8) and the larva hatches and gnaws the inner surface of the stalk, too late to prevent the formation of the head, but early enough to shorten it and hinder the filling of the kernels. To ascertain the amount of this injury 1,452 heads taken from an apparently unin-

jured field of winter wheat near Pullman, Wash., were dried and weighed. Thirty-nine per cent of these were afterwards found to have grown upon stems damaged by the strawworm, and the average weight of the heads from these damaged stems was 22 per cent below the average of healthy heads, although no difference in size was noticeable until the heads were placed side by side, when it was found that most of the larger heads were those from uninjured plants, while most of the shorter ones were from infested plants. Between heads of the same size there was a difference of 7 per cent, which could not be detected except by weighing.

Both the work of the spring brood in fall wheat and that of the summer brood in spring and winter wheat are so carried on that the owner does not know of his loss unless it amounts to a very large percentage of the crop, and even then he may attribute it to some other cause. The presence of a large number of unusually rank and apparently sturdy plants among the winter wheat does not seem alarming, but the reverse; and there is no other indication of work of the spring brood. Later, when these infested plants begin to die they are concealed by the yellowing blades of the healthy plants, so that even the trained entomologist can hardly find them. The same is true of the spring wheat which is attacked by the summer brood, while winter wheat plants attacked by the summer brood are, as we have just shown, so little altered in appearance that the presence of the insect can be detected only by weighing the heads or splitting the stems to look within for the larvæ.

Many of the larvæ remain in the stubble if the grain is cut with a harvester, and most of them if it is cut with a header. They begin to pupate during the latter half of July, but many remain in the larval condition until May of the following year.

The life history just related shows that strawworm injury is induced by growing crops of winter wheat repeatedly upon the same ground; by leaving volunteer plants among the spring wheat; by allowing summer fallow to grow foul with volunteer wheat, even at a distance from wheat fields; and by growing spring wheat near winter wheat. All of these cases occur at times in the wheat country which we are considering. The essential conditions in each of these cases are, first, the presence of infested stubble, plowed or unplowed, to furnish the early adults; second, a growth of winter or volunteer wheat early in the spring to receive the eggs of the first generation; third, a crop of winter or, preferably, spring wheat to receive the eggs of the second brood. The remedy lies in avoiding these conditions by rotation of crops, clean early summer fallowing, and the abandonment of spring-wheat culture. Fall plowing of the stubble does not prevent the insects from coming out and attacking wheat in the

spring. Burning the stubble is impracticable, because the joints which contain the larvæ remain sappy during the fall and will not burn. Rotation, to be effective, must be planned with reference to the work of the insect, since two adjoining fields which are in wheat in alternate years have between them a strip 2 rods wide which always furnishes ideal conditions for its spread. The stubble in one field always furnishes insects to attack the growing wheat in the other, and while the damage done by the wingless first generation is limited to the 1-rod strip next the fence, the winged second generation spreads at will through the field.

There is no reason why an insect, so readily held in check merely by careful farm methods, should cause constant loss and an occasional menace to the wheat country of the Northwest, but there is no doubt that it does so.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *April 10, 1909.*

[Cir. 106]

O

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

**WHAT CAN BE DONE IN DESTROYING THE COTTON BOLL
WEEVIL DURING THE WINTER.**

By W. D. HUNTER,

In Charge of Southern Field Crop Insect and Tick Investigations.

IMPORTANCE OF WINTER WORK.

The boll weevil attracts greatest attention during the growing season of cotton, for the simple reason that its damage is then most evident. When the infested squares are falling by millions every day the planter is driven to most strenuous efforts to check the loss. The summer season, however, is the one in which it is most difficult to combat the weevil. The pest can be attacked in various ways at different seasons of the year. This circular attempts to point out what can be done in the winter when the weevils are in hibernating quarters and when natural conditions are assisting the farmer greatly by reducing the number that will be able to survive until spring. At this time the farmer can undoubtedly accomplish more than by hand-picking weevils and squares or any other direct method of control that can be put into operation in the summer season. A great advantage that winter work has in many cases is that it involves no special outlay and consequently adds nothing to the cost of producing cotton. The work can be done during the quiet period of the winter and at such times as will not interfere with the general work of the plantation. Even on plantations run largely or entirely by "wages hands" this work would undoubtedly warrant an outlay on the part of the planter. As a matter of fact the winter season could well be made the most active of the year as far as the destruction of the weevil is concerned.

It is true that the Texas farmers have not paid much attention to work against the weevil in the winter, but this does not by any means indicate that such work will not be of prime importance to the planters in Louisiana and Mississippi. Nature has afforded the Texas farmer many advantages over the planter in the eastern part of the cotton belt. As has been pointed out in other publications of the Bureau of Entomology, the Mississippi Valley planter will be compelled to contend against many more weevils each spring than the climatic conditions in Texas have ever permitted to survive. For instance, in the spring of 1908 it was determined by Mr. Wilmon Newell, secretary of the State crop pest commission of Louisiana, that as many as 6,000 hibernated weevils per acre made their appearance in certain cotton fields in Avoyelles Parish, Louisiana. This shows a survival of weevils far beyond what has ever been found in Texas. There are many other indications of the special seriousness of the weevil problem in the Mississippi Val-

ley. All this demonstrates that the planters in regions recently invaded by the weevil must resort to every means of control that is known and must utilize to the fullest extent such methods as the Texas farmers may not have been compelled to practice.

The all-important step in the control of the weevil is the destruction of millions of individuals and the prevention of the development of many more by uprooting and burning the cotton plants in the fall. This is a step that indications show clearly is going to be indispensable in the Mississippi Valley. In the light of what is now known it would be folly for planters to attempt to produce cotton unless they follow this practice religiously. If, for any reason, the cotton plants have not been removed in the fall, some good can be accomplished by their removal later in the season. The proper thing to be done by the planter who desires to reduce weevil damage to the minimum is to combine the fall destruction of the plants with such measures, to be taken later in the season, as are outlined in this circular. *The advice now given is not to depend upon winter work altogether for the control of the weevil. The winter work is merely a second step, to be taken in connection with the destruction of the weevils and the prevention of the maturity of the fall broods by uprooting and burning the plants. Where that step has not been taken, the work outlined in this circular is the main dependence of the planters at this time.*

WHERE WEEVILS ARE TO BE FOUND DURING THE WINTER.

The whole question of what can be done to destroy the weevils in the winter depends upon where they are to be found. The Bureau of Entomology has taken pains to determine the localities in which the weevils secrete themselves during the winter months. Some weevils fly outside of the cotton fields into the timber before frost has killed the cotton. Of course, such individuals as fly great distances from the cotton fields, or into heavy timber, are entirely beyond the reach of the planter. The remainder of the weevils, however—those remaining in and about the cotton fields—are more or less at the mercy of the planter for several months during the winter.

In cotton fields and in their immediate vicinity weevils have been found hibernating in four principal situations: *First*, in burrs and unopened bolls on the plants; *second*, in bolls or portions of bolls that have been knocked to the ground; *third*, under such trash as leaves and grass abounding in most cotton fields; *fourth*, in the cracks in the ground caused by drying.

The numbers of weevils found in the situations just mentioned show clearly what opportunities the farmer has for their destruction. On January 16, 1907, a field near Wolfe City, Tex., showed from 363 to 1,500 live weevils per acre in the burrs still hanging to the plants. These were generally in the partly opened locks where weevils had matured in the fall, but some were in locks from which all of the cotton had been removed. On January 27, 1907, as many as 2,250 weevils per acre were found on the ground in a cotton field near Dallas, Tex. The number was determined by raking all of the trash carefully from a square rod of ground and examining it in the laboratory. On December 18 living weevils at the rate of 1,056 per acre were found at Dallas. On January 16 320 living weevils per acre were found in burrs and under leaves and grass in a cotton field at Victoria, Tex. On Novem-

ber 15 4 weevils were found in the cracks around the bases of 22 cotton plants growing near Dallas. This indicates a total number of weevils per acre in such situations in this field of 1,090.

Practically all of the weevils to be found in the situations described can be killed by raking and burning the trash, except those in cracks in the ground, and these, in the majority of cases, would probably be crushed by winter plowing of the fields.

PLOWING NOT EFFECTIVE.

The point may be raised that winter plowing, by burying the weevils found in trash on the surface, might have the same effect as burning. On the contrary, experiments have shown that weevils can easily make their way through several inches of soil. Consequently such work in general is as likely to protect as to destroy the weevils. Of course, if heavy rains should follow immediately after plowing, it is possible that some soils would be so compacted as to prevent the emergence of weevils. Nevertheless, this could not happen under usual conditions. In the case of weevils in cracks, destruction would not result from burial but from crushing.

What has just been stated should not be taken to mean that winter plowing should not be followed. As a matter of fact, the winter working of the fields should be practiced, not only on general principles, but to assist in procuring an early crop. The present purpose is merely to point out how to destroy the boll weevil in the winter. Regardless of its other benefits, winter plowing can not be depended upon to actually kill many weevils.

WEEVILS THAT CAN BE REACHED OUTSIDE OF COTTON FIELDS.

In addition to those in the cotton fields themselves, many weevils can be reached that have found winter quarters along turn-rows, in ditches, along fences, and in the trash that is frequently allowed to accumulate around seed houses. Fire is again the agent of destruction at the command of the farmer. Careful burning of turn-rows and ditches and cleaning of fence corners and similar situations will result in the death of many weevils that might survive to damage the crop of the following season.

The work of burning and cleaning the plantation should not stop with the immediate vicinity of cotton fields. Many weevils fly into corn fields, where they find suitable quarters for passing the winter. These fields, on a cotton plantation, should be cleaned during the winter as thoroughly as the fields where cotton has been growing or is to be grown during the next season. It has been found that sorghum fields furnish exceptionally favorable opportunities for hibernating weevils. The heavy stubble left by this crop catches grass and general debris blown about by the wind, which then becomes heavily matted. Here many weevils are to be found during the winter. In many cases in Texas the earliest appearing weevils and the greatest damage to the crop have been shown to be chargeable to neighboring sorghum fields which have served as winter quarters for the pest.

Many weevils undoubtedly find hibernating quarters in trash along railroad rights of way as well as along wagon roads. The importance of such means furnished the weevil for passing the winter becomes great where, as in many cases, the roads or railroads pass through localities

where cotton fields adjoin the public property. It should be the duty of railroad and county authorities in such cases to assist the farmers as far as practicable by removing the shelter for the weevil.

WEEVILS IN COTTON SEED.

Cotton seed has frequently been supposed to furnish exceptionally favorable winter quarters for the weevil. It has been shown that many weevils pass through the gins and are later to be found in the bulk cotton seed in storage. Up to a certain time in the winter cotton seed is very likely to contain live weevils. Many experiments, however, have shown that very few are able to survive in this medium until spring. This seems to be due principally to the absence of moisture. Repeatedly numbers of weevils have been placed in cotton seed in the fall. Altogether 6,600 weevils have been used in these experiments. They were placed under a variety of conditions. Although many have survived until the middle of winter, only two lived until the first of April. It is therefore clear that cotton seed itself is not an especially dangerous commodity. Although it is true that the earliest weevils frequently make their appearance in the vicinity of seed houses, this is to be accounted for by the fact that the insects find quarters under the building and under the trash that is allowed to accumulate in such situations rather than in the cotton seed itself.

CONCLUSION.

The climatic and labor conditions surrounding cotton production in Louisiana and Mississippi leave no doubt that the planters in those States must not overlook any important means of controlling the boll weevil. *This circular points out one important and inexpensive means that can be practiced by every planter.* It is of special importance in the humid regions recently invaded where fears of disaster are now commonly entertained. The Department of Agriculture urges that cotton raisers take advantage of the enemy while they have the opportunity and by the means herein described greatly increase the chances for producing a crop the coming season.

Approved:

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., December 19, 1908.

A6—31

United States Department of Agriculture, BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

HOUSE FLEAS.

By L. O. HOWARD.

Judging from the specimens of fleas sent to the Bureau of Entomology of recent years with complaints of houses being infested by them, the human flea (*Pulex irritans* L.) is not the species most likely

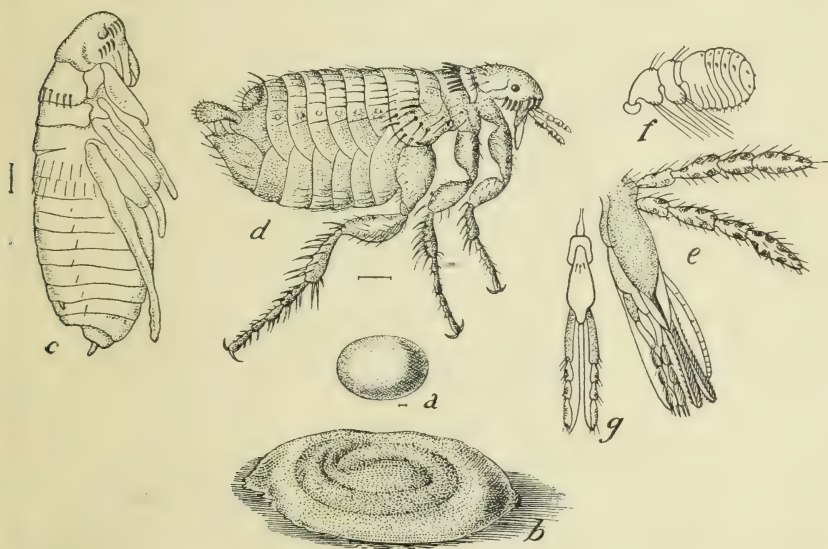


FIG. 1.—Cat and dog flea (*Ctenocephalus canis*): *a*, Egg; *b*, larva in cocoon; *c*, pupa; *d*, adult; *e*, mouth-parts of same from side; *f*, antenna; *g*, labium from below. *b*, *c*, *d*, Much enlarged; *a*, *e*, *f*, *g*, more enlarged. (Author's illustration, redrawn.)

to occur in great numbers in dwelling houses in this country, but rather the common, cosmopolitan flea of the dog and cat (*Ctenocephalus canis* Curtis).^a This holds especially for the eastern

^a In the earlier publications of this office, Bulletin 4 and Circular 13, this species has been referred to under the name *Pulex serraticeps* Gerv.

United States. *Pulex irritans* is sometimes found in houses in California, and is the prevailing household flea of Europe. A house may become infested with the cat and dog flea even though no domestic animals be kept, for a visitor at a house where such pets are maintained may be the means of carrying home with him one or two female fleas which will stock his own premises. Of course, where a pet dog or cat is kept, the source of the infestation is manifest.

The worst cases of infestation reported to this Bureau have usually been those in which houses had been temporarily unoccupied during the summer. Such houses during a rainy summer become more or less damp, and as a rule the customary sweeping of the floors is interrupted, thus furnishing the very conditions under which, as we shall see, fleas most readily propagate.

The eggs (fig. 1, *a*) of *Otenocephalus canis* are deposited among the hairs of cats and dogs, but as they are not attached to the hairs, numbers drop off whenever the infested animal moves or lies down. From these eggs hatch the larvæ (fig. 2, *a*), which are slender, minute, white, wormlike creatures. They are very active, crawl rapidly, penetrate into the cracks of the floor, and live there until full grown, feeding upon such organic matter as may have collected in the cracks. They develop rapidly, and in midsummer in Washington reach full growth in a short time. On reaching full growth the larva spins a delicate, white, silken cocoon (fig. 1, *b*), and transforms to pupa (fig. 1, *c*), the adults (fig. 1, *d*) issuing a few days later. A whole generation may develop in the course of a fortnight in warm, damp weather, but a great excess of moisture results in the destruction of the larvæ. With this rapid development under the most favorable conditions, a housekeeper, shutting up her house in June, for example, with a colony of fleas too small to be noticed inside the house, should not be surprised to find the establishment overrun with fleas when she opens it again in September or October.

REMEDIES.

If you do not desire to be troubled by fleas, do not keep cats or dogs. If you must keep a pet dog or cat, provide a rug for the animal to sleep on, and give this rug a frequent shaking and brushing, afterwards sweeping up and burning the dust thus removed. As all the flea eggs on an infested animal will not, however, drop off in this way, and as those which remain on it will probably develop successfully, it will be found wise to occasionally rub into the hair of the dog or cat a quantity of pyrethrum powder. If thoroughly applied, this powder will cause the fleas to fall off in a half stupefied condition, when they, too, may be swept up and burned.

The larvæ of the dog and cat flea will not develop successfully in situations where they are likely to be disturbed. The use of carpets

and straw mattings, in the writer's opinion, favors their development, since the young larvæ can penetrate the interstices of either sort of floor-covering and find an abiding place in some crack where they are not likely to be disturbed. It is comparatively easy to destroy the insect in its early stages (when it is noticed), but the adult fleas are so active and so hardy that they successfully resist any but the most strenuous measures. Even the persistent use of California buhach and other pyrethrum powders was ineffectual in one case of extreme infestation, as was also, and more remarkably, a free sprinkling of floor mattings with benzine. In this instance it was finally necessary to take up the floor-coverings and wash the floors down with hot soapsuds in order to secure relief from the flea plague. In another case, however, a single liberal application of buhach was perfectly successful, while in a third a single thorough application of benzine completely rid an infested house of fleas.

In bad cases almost nothing will avail without the greatest care in keeping the floor and other coverings, as well as crevices, etc., free from dust and dirt. The old remedy often mentioned of putting a piece of raw meat upon a sheet of sticky fly paper, in the hope that the fleas will jump for the meat and be caught by the fly paper, has been thoroughly tried by the writer without success. Where there are comparatively few fleas in a house or in a given room, the following somewhat laborious plan will result in eradication. Place a white cloth, like a pillowcase, in the middle of the floor. The fleas, attracted by the white color, will jump on the cloth. Then, with a basin of water, kneel down and with the wetted forefinger pick up the fleas one after another and put them in the water. The writer has known several houses in Washington to be rid of rather sparse populations of fleas in this manner.

Mr. E. M. Ehrhorn, of San Francisco, gives the following remedy, which he states he has tested and which his mother used with effect in South America. Fill a glass three-fourths with water, on top of which pour about an inch of olive oil, then place a night float (a little wick inserted in a cardboard disk or in a cork disk) in the center of the oil. Place the tumbler in the center of a soup plate filled with strong soapsuds. The wick should be lighted at night on retiring, or may be used in any dark room. As the soup-plate-soapsuds trap is placed on the floor of the room it does not interfere with the sleeper, and the fleas which are on the floor are attracted to the light. For outbuildings, such as barns, etc., a large milk pan may be used, and instead of using olive oil and a glass, a stable lantern may be placed in the center of the pan, while instead of soapsuds a scum of kerosene may be put on the water in the milk pan.

To sum up: Every house where a pet dog or cat is kept may become seriously infested with fleas if the proper conditions of moisture and freedom from disturbance exist. Infestation, however, is not likely to occur if the (bare) floors can be frequently and thoroughly swept. When an outbreak of fleas comes, however, the easiest remedy

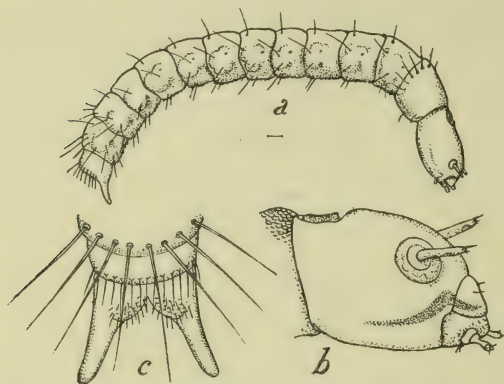


FIG. 2.—Cat and dog flea (*Ctenocephalus canis*): a, Larva; b, head of same; c, anal end of same. a, Much enlarged; b, c, more enlarged. (Author's illustration, redrawn.)

to apply is a free sprinkling of pyrethrum powder in the infested rooms. This failing, benzine may be tried, a thorough spraying of carpets and floors being undertaken, with the exercise of due precaution in seeing that no lights or fires are in the house at the time of the application, or for some hours afterwards. Finally, if the plague is not thus abated, all floor coverings must be removed and the floors washed with hot soapsuds. This is a useful precaution in any house which it is proposed to close for the summer, since even a thorough sweeping may leave behind some few flea eggs from which an all-pervading swarm may develop before the house is reopened.

Approved:

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., December 29, 1908.

[Cir. 108]

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE LEOPARD MOTH.*(Zeuzera pyrina Fab.)^a*

By L. O. HOWARD and F. H. CHITTENDEN.

INTRODUCTORY.

Deciduous trees of many kinds, grown for shade and for ornament in northern New Jersey and eastern New York, are subject to severe injury by the larval stage of the European leopard moth (*Zeuzera pyrina* Fab.). Among the shade trees, elms and maples suffer the greatest damage, but as this species is a very general feeder it attacks practically all descriptions of trees and shrubs with the exception of the evergreens. In the region mentioned this species is, everything considered, the most serious menace to the growth of shade trees, since, unlike the majority of lepidopterous insects, the larvæ of the leopard moth do not feed upon the foliage, but bore into the branches of the plants which they infest and feed upon the living wood. The larvæ usually begin operations in twigs and small branches and with their larger growth bore and tunnel into the larger branches and trunks. This work has the effect of girdling, the injured portions being blown down by heavy wind storms, while in the case of severe attack the growth of the tree is checked, frequently causing its death. Attack is not confined solely to shade and ornamental plants, but orchards are often injured.

DESCRIPTIVE.

Injury by this species is accomplished solely by the larva, which is a fleshy, grublike caterpillar, pale yellowish in color, frequently with a pinkish tinge. The head, thorax, and anal plates are brownish-black and the surface of the body is very sparsely hairy but covered

^a Family Cossidæ. Synonyms: *Zeuzera æsculi* L., *Z. decipiens* Kby., etc.

with large and prominent tubercles arranged as shown in the illustration (fig. 1, *c*). When fully mature the larva attains a total length of about 2 inches. A lateral view of the larva in its burrow is shown in figure 1 at *c*.

This species derives its name from the spotted appearance of the moth, illustrated at figure 1, *a*, *b*. There is great diversity in the size of the two sexes, the female (*a*), which is a heavy-bodied moth and a very feeble flyer, being much the larger. It will be noticed that the smaller male (*b*) has a more slender body, which permits a more ready flight, and is also distinguished from the female by the pos-

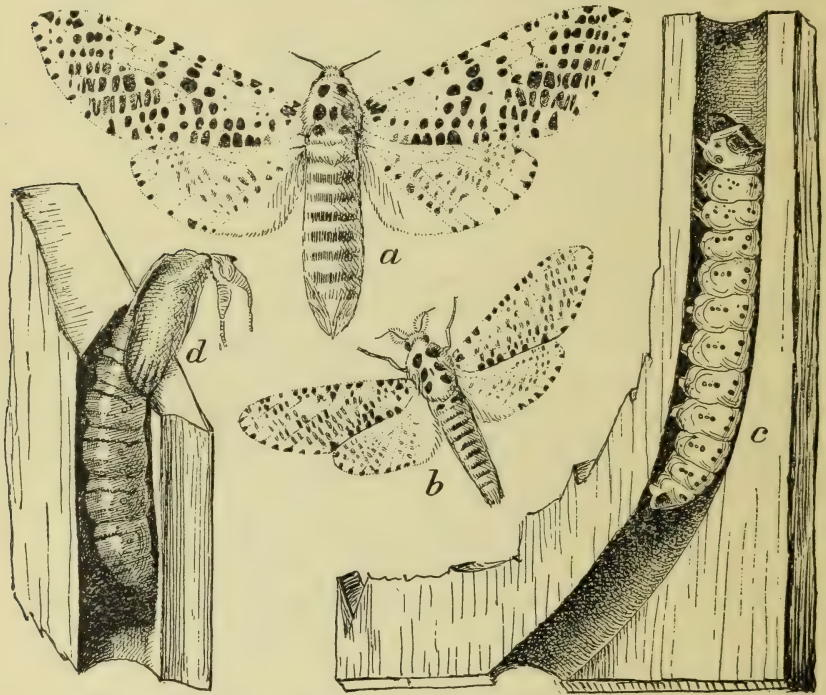


FIG. 1.—The leopard moth (*Zeuzera pyrina*): *a*, Adult female; *b*, adult male; *c*, larva; *d*, empty pupal case. Enlarged. (Original.)

session of broad bipectinate or feathery antennæ. The wings are semitransparent and white, thickly dotted with blackish spots which are more or less distinctly tinged, giving them a dark blue or greenish cast. The thorax is marked with six large black spots and one small one, the latter being located in the center. The female has a wing expanse of upwards of one and a half inches, while that of the male is much less.

An empty pupa-case in its cell in the wood is shown in the illustration at *d*.

ORIGINAL HOME AND DISTRIBUTION.

The leopard moth, like so many other dangerous pests, is a European species which has been introduced into the United States in comparatively recent years. Its old world distribution is credited as central and southern Europe, southern Sweden, southwestern Africa, Algeria, and northern Morocco, and the western portion of Asia Minor.

This species was introduced into the United States some time prior to 1879, in which year, on the authority of Mr. Jacob Doll, a living moth was captured in a spider's web at Hoboken, N. J.^a In 1884 Dr. E. B. Southwick, then entomologist of the public parks of New York City, recognized the destructive work of this species in Central Park.^b In 1887 it was seen at Newark, N. J., but was not actually recorded as occurring in this country until the following year. In 1890 the junior author observed the moths at electric lights at Orange, N. J.

Fortunately the spread of this insect, particularly in the immediate vicinity of New York City, has been very slow, a fact which may be attributed to several causes, (1) the slowness of the flight of the female, (2) the dominance of sparrows in large cities, causing our native birds, such as woodpeckers, to be driven to the country, where they destroy the moths, and (3) the bowl-shaped electric-light globes, hollow at the top and closed at the bottom, which were formerly in general use in our large cities. The males are strongly attracted to brilliant lights and many were captured and perished in these globes in earlier years. Other cities in New Jersey where this species has been troublesome are Elizabeth, Irvington, Montclair, Arlington, Asbury Park, Ocean Grove, and New Brunswick. Mr. H. M. Russell of this Bureau collected specimens at Bridgeport, Conn., in 1901. The species is now an inhabitant also of Staten Island and has spread on Long Island well beyond the confines of greater New York. Southward it was reported a pest, in 1901, at Ocean Grove, N. J., and by 1905 it was recorded by Felt as occurring at Kensico, N. Y., 25 miles north of New York City. By 1907 it was captured at New Haven, Conn., by Prof. H. W. Foote. It is now stated to be injurious in the vicinity of Boston, Mass.

FOOD PLANTS.

In its original home the leopard moth is recorded as living on a considerable number of common trees, including elm, lime or linden, ash, beech, birch, walnut, oak, chestnut, poplar, alder, and, rarely, horse-chestnut. Among orchard trees it is reported to do injury to pear, apple, and plum. In the United States it attacks all of these

^a Entomological News, March, 1904, p. 110.

^b Insect Life, Vol. VII, p. 138.

trees and many others, the list including such important shade trees as have been mentioned, as also practically all of the maples, elms, and oaks, mountain ash, tulip tree (*Liriodendron tulipifera*), aspen, the willows, and such shrubs as privet, lilac, and honeysuckle. A list of trees which this species has been actually observed to attack was compiled in 1894 by Doctor Southwick and includes 77, observed in the public parks of New York City alone. A total list of 83 trees and shrubs was made at that time.^a

It will be seen by the list of food plants already presented that the number could be almost indefinitely extended, particularly in reservations like Central Park, New York City, and Prospect Park, in Brooklyn, where special effort has been made to bring together a great variety of trees and shrubs. The insect is, in fact, nearly omnivorous, attacking, as previously stated, practically all forms of woody plants which are of suitable size for its purpose, with the exception of conifers.

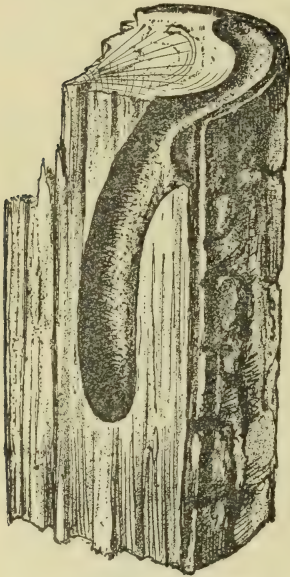


FIG. 2.—Section of wood showing burrow and girdling effect produced by larva of leopard moth. Reduced. (From Insect Life.)

HABITS AND LIFE HISTORY.

In Germany the moths are stated to make their appearance during July and August, while in this country they appear as early as May and continue issuing until late in September.

The gravid female, being particularly heavy, is unable to fly very far or very high. She deposits her oval, salmon-colored eggs in a large mass or group, when not in confinement, and as many as 300 eggs have been counted in a single mass. This is, however, probably not the maximum number, since an estimate of as many as 1,000 has been made. The eggs are introduced by the rather hard ovipositor into the soft tissue of young growth where the bark is smooth, or are inserted into crevices in the rough bark of older trees.

The larvæ soon hatch—in about ten days, according to Mr. J. V. D. Walker—and penetrate the wood, frequently entering the nearest crotch but boring in at other points, and burrow tunnels into the heart or pith of twigs and the heartwood of the larger branches or trunks. When a larva has grown too large for the branch in which it is feeding it crawls out and migrates to a larger one. In a single

^a See list on page 529, Rep. Ent. N. J. Agr. Exp. Sta. for 1894. This article, by Dr. J. B. Smith, covers pages 517–533 and presents a very complete account of the insect.

tree 6 inches in diameter Southwick observed as many as six larvæ, any one of which would have been able to destroy the tree if not removed. Mr. A. Hufnal wrote that in maple trees which this species was infesting at Ocean Grove, N. J., there was an average of from six to eight borers to a tree and that he had found from ten to fifteen, and in one instance as high as thirty-four, in a single tree. By the time the larvæ within have attained full growth infested limbs of a certain size are likely to break off, especially during or after a severe storm, for the full-grown larva in many cases girdles the branch. The manner of girdling is shown at the top of the section of wood illustrated in figure 2. In 1893, after every storm in Central Park great quantities of limbs were seen, some entirely broken off and others still hanging to the trees.

The larva, when fully mature, transforms to pupa within the burrow, the change beginning to occur during the second May after the hatching of the eggs, the larva thus requiring nearly two years to complete its growth. The pupa, by means of a sharp protuberance on its head, is enabled to force its way partly out of the burrow, after which the skin splits open and the moth emerges. The empty pupal skin remains for some time projecting from the orifice.

The presence of this borer in a branch is manifested by little accumulations of chips, matted excrement, or frass, which indicate the entrance to the burrows. After a time these orifices are closed from within by a silken web, which is doubtless to protect the contained insect from its natural enemies. Smaller twigs wilt and break off and often it is only when the severed twigs or branches have been brought down in numbers by high winds that the work of the insect is first recognized. Where the larger larvæ have worked just under the bark this splits open the next season, leaving an ugly scar as a reminder of its pernicious operations.

NATURAL CHECKS.

No specific natural enemies of the leopard moth appear to have been recorded in this country, although in Europe E. A. Fitch has reared an indeterminate chalcidid of the subfamily Encyrtinæ.^a

In the explanation of the cause of the slow spread of the moth from cities and large towns to the country, allusion has been made to the fact that native birds probably assist in holding this insect in check in the suburbs. Actual observations on this head appear to be wanting, but there are the best of reasons for believing that birds, like the woodpeckers, which naturally look over the bark and collect all kinds of borers, prey on this species, while it is believed

^a Entom. Mo. Mag., Vol. XVIII, p. 116. Perhaps *Copidosoma truncatellum* Dalm., mentioned by Dalla Torre (not Mayr), Catalogus Hymenopterorum, p. 246.

that sparrows sometimes destroy the eggs or young larvæ in such places. Smith has expressed the belief that when the insect succeeds in getting away from the outskirts of cities its enemies increase in number, many insectivorous birds aiding in holding it down.

During the day the moths must be fed upon by birds and later by bats and night-flying birds. The habit of the larvæ of deserting one twig and migrating to a larger one undoubtedly leaves them exposed to the same natural enemies, as this has been observed to happen in the daytime as well as after nightfall. It follows that the protection of native birds, especially the woodpeckers and related species, will greatly assist in restraining the undue increase of this borer.

METHODS OF CONTROL.

The protected and concealed manner of life of this species, as shown by the life history, which will apply in the main to other borers also, renders it very difficult of treatment by means of insecticides or other direct measures. The most efficacious remedial measure consists in cutting off and destroying affected branches and in the injection of bisulphid of carbon into the holes or burrows where the larvæ are at work.

Pruning and cutting back.—Twigs or branches which, by their wilting or by the frass which accumulates at the entrance to their burrows, indicate the presence of this borer, should be carefully searched out, the smaller ones pruned away and the larger ones cut back, the amputated portions being promptly burned. After windstorms, the affected branches which have fallen to the ground and those which remain attached to the tree should be collected and burned. Wherever trees show that they are past recovery it is best to take them out and promptly destroy them. The word promptly is used advisedly, for this insect, as has been shown previously, frequently migrates from one twig or branch to another.

Bisulphid of carbon.—In the case of young and rare trees and others which show only a few larval burrows in the bark, bisulphid of carbon is the best remedy and one which has been in general use against the present species in the public parks of New York City. It is injected into the openings of the burrows, and the openings are afterwards closed with various substances. For this injection a mechanic's long-spouted oil can of small size may be used on large trees, but against a related species the writers have made very good use of a small glass syringe, such as may be purchased at any drug store for ten cents. These glass syringes are most serviceable, because the exact amount of bisulphid may be seen when drawn into the syringe and because the reagent does not injure the thread pack-

ing.^a Metal syringes may also be used, but it is more difficult to measure the exact amount and the bisulphid acts on the leather packing. Rubber syringes can not be used because of rapid corrosion. About a teaspoonful of the liquid bisulphid is sufficient for each burrow.

For stopping the holes after injecting the liquid, putty and moist clay, advised by some, have not been found so serviceable as grafting wax. Coal tar may be substituted for the latter, or the holes may be closed by inserting a wooden plug and breaking or sawing it off level with the trunk. In any case the stopper should be tight, to exclude water from rains, which might tend to produce decomposition of the surrounding wood or invite other insects, like black ants and secondary borers, of which there are many species, and injurious fungi.

Carbon bisulphid should be handled with the usual precautions against fire, which means that the operator should not smoke while at work. Although a deadly poison, it will not injure ordinary trees when applied as described.

Killing with wires.—It is possible to reach and destroy some larvæ by forcing a copper or other pliable wire into the channels. This is a well-known borer remedy. It is impossible, however, by this means to kill the insects in all cases, owing to the length or crookedness of the burrows. Bisulphid of carbon should then be used.

Electric lights.—To what extent electric lights are serviceable as an agency in the destruction of the moths of this borer has not been definitely determined. Col. Nicholas Pike and Dr. J. B. Smith, however, have advised placing shallow pans around electric-light poles in and around parks to attract the moths. The pans are partially filled with water and a few drops of kerosene are poured into them. The moths flying against the globes drop into the pans and are promptly killed when they come into contact with the oil. In this way many males can be destroyed.

Inspection.—In large parks the destruction wrought by this borer annually is an important item, and it will be found a source of profit to establish a system of inspection consisting in the employment of parkkeepers and boys, and others who may be engaged at lower

^a During the last years of the nineteenth century a long row of beautiful red oaks bordering the street between the grounds of the Department of Agriculture and those of the Smithsonian Institution were badly infested by the related carpenter worm (*Prionoxystus robinix* Forst.). Nearly every tree was infested and frequently two or three burrows showed near the tops of the trunks. Bisulphid of carbon was applied, as described above, and the holes closed with grafting wax. A year later no insects could be found at work, but wherever this remedy had been applied a small scar remained. Two years later these had entirely disappeared and the trees looked as if they had never been infested.

wages, to keep a constant lookout for evidences of borer attack on valuable trees. On this head Southwick has reported that in 1893 he spent two months in fighting this insect alone in the city parks of New York, collecting wagon loads of limbs and branches and destroying the larvæ or pupæ.

Maintaining trees in thrifty condition.—If valuable trees are to be protected, the insect should not be allowed to breed in useless growth. The borers in such trees should be destroyed or the trees promptly felled and burned. Care should be exercised in transplanting new trees, and fertilizers should be used in order that the trees may be always thrifty, the better to withstand attack. This means protecting them from the attack of aphides, scales, and defoliators, such as tussock moths and the fall webworm, and keeping them free from disease.

Finally, in the control of this species promptness and thoroughness can not be too strongly emphasized. The bisulphid of carbon remedy should always be used where applicable, and the inspection system advised should be instituted in all public parks and on city streets infested by this pest. Individual owners of valuable trees should become acquainted with the pernicious nature of this borer, and united action should be secured with neighbors who also suffer from the ravages of the pest.

NOTE.—After this publication was in type we received information that trees in the college yard of Harvard University, Cambridge, Mass., are being severely injured, the large elms being the most seriously attacked.

Approved:

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., May 27, 1909.

[Cir. 109]

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE GREEN-STRIPED MAPLE WORM.*(Anisota rubicunda Fab.)^a*

By L. O. HOWARD and F. H. CHITTENDEN.

GENERAL APPEARANCE AND METHOD OF WORK.

Maple trees grown in the United States for shade or other purpose are subject to severe injury from defoliation by caterpillars. In addition to the fall webworm^b and tussock moth caterpillar^c there is a common and troublesome species known as the green-striped maple worm (*Anisota rubicunda*) which affects maples of all kinds, including sugar maple, and is especially partial to silver and swamp maples. It feeds occasionally also on box-elder and will defoliate oak in the absence of its favorite food trees.

In its active stage this insect is a naked or hairless caterpillar (fig. 1, *d*, *e*) of large size and somewhat attractive appearance, being pale yellowish green, longitudinally striped with dark green. It is armed just back of the head, on the second thoracic segment, with a pair of long black horns. It has also a number of short, black, spiny projections along its sides and at its anal extremity. The anal segments are somewhat dilated and rose-colored on the sides. When fully grown, it measures nearly two inches in length.

The parent insect, or moth, is a beautiful creature of a pale yellow color shaded with a most delicate pink. The female is well shown in the accompanying illustration (*a*), the dark portions representing the pink, and the paler portions the yellow color. In eastern individuals the colors differ from those found in the West, the rose tints being more intense, while in the western forms the yellow predominates, with only a slight tinge of rose. Some western individuals also are nearly white. The female has a wing spread of one and three-fourths to about two inches, and her body is yellow and woolly in appearance. Her head is small, retracted into the thorax, and bears short, thread-like antennæ. The male is smaller than his mate, having plumose or feathery antennæ, as represented in the figure (*♂*).

The egg is about one millimeter in diameter, slightly flattened, and pale green, becoming yellowish before the larva hatches. A portion of

^a Formerly called *Dryocampa rubicunda* Fab.^b *Hyphantria cunea* Dru.^c *Hemerocampa (Orgyia) leucostigma* Dru.

an egg mass is figured in the illustration at *c*, and a much-enlarged egg with the embryo within at *b*. The pupa is very dark brown, nearly black, and of the somewhat peculiar form shown at *f*. It is armed with little spines on the margin of the abdominal segments and on the thorax, and the anal segment ends in a projection a little forked at the tip.

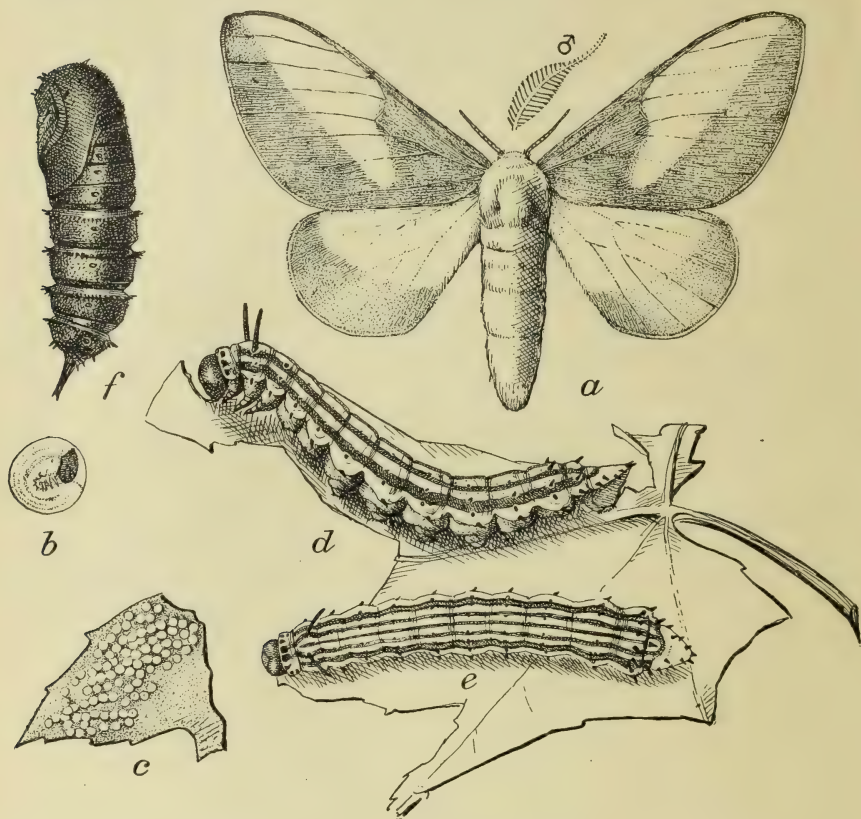


FIG. 1.—*Anisota rubicunda*: *a*, Female moth and antenna of male moth; *b*, egg showing embryo within; *c*, portion of egg mass; *d*, full-grown larva from side; *e*, same from back; *f*, pupa. Enlarged. (Original.)

ORIGIN AND DISTRIBUTION.

The green-striped maple worm is a native North American species and is more abundant in the West than in the East, although it enjoys a considerable range. It abounds especially in Kansas, Nebraska, Missouri, Illinois, and Iowa, occurring also in the Gulf States, occasionally doing considerable damage in Mississippi. It extends sometimes in injurious numbers North and East, and has attracted some attention by its ravages in West Virginia, the District of Columbia, New Jersey, and in a limited portion of New York State. Instances

are on record of its occurrence in great numbers in Dutchess and Sullivan counties in New York, but these occurrences were exceptional.

LIFE HISTORY AND HABITS.

The moths issue from over-wintering pupæ or chrysalides in May or June, according to locality, and pair, the females depositing their eggs on the under side of the leaves. The number of eggs laid by a single female has not been ascertained, but is known to reach at least 150. In eight or ten days the eggs hatch, and the caterpillar emerges and feeds and grows apace. After passing through four molts in about a month it reaches full growth, when it enters the ground to transform to pupa. At the end of two weeks, or a little longer, the pupa, by means of the sharp and horny projections which have already been described, works its way to the surface of the ground and gives forth the moth. Soon afterwards the female, after copulation, lays eggs for a second generation.

In the District of Columbia it has been ascertained that there are usually three generations in the course of a year, although in Missouri, according to Riley, there are only two. Pupæ of the second generation in the West and of the third generation in the East over-winter. Even as far north as Massachusetts Harris showed the probability of two generations annually.

INSTANCES OF INJURY.

Many of the earlier writers on economic entomology reported numerous instances of injury by this species, but of late the insect has not received much attention, presumably because of the far greater destructiveness of the commoner tussock moth and fall webworm, and of the gipsy and brown-tail moths. Possibly this maple worm is decreasing in numbers. Some characteristic outbreaks may be mentioned, therefore, as showing its importance some years and to give some idea of its method of work.

In 1887 Mr. H. W. Young, Independence, Kans., wrote that for four years the soft maple shade trees of that city had been defoliated twice a year by this insect, the trees being greatly weakened. In 1888 Mrs. M. T. McCluny, Sedalia, Mo., wrote that these "worms" "were like the locusts of Egypt, and filled the houses" and destroyed the leaves of the maple shade trees. In 1889 considerable correspondence was had with Mr. J. W. Merchant, Kansas City, Mo., who reported extensive defoliation in Kansas City, Kans., and sent several photographs, one of which is here reproduced (fig. 2). In cases where adjoining maple and elm trees branched into each other the elm trees were never touched. During the period from 1888 to 1890, at Lincoln, Nebr.,

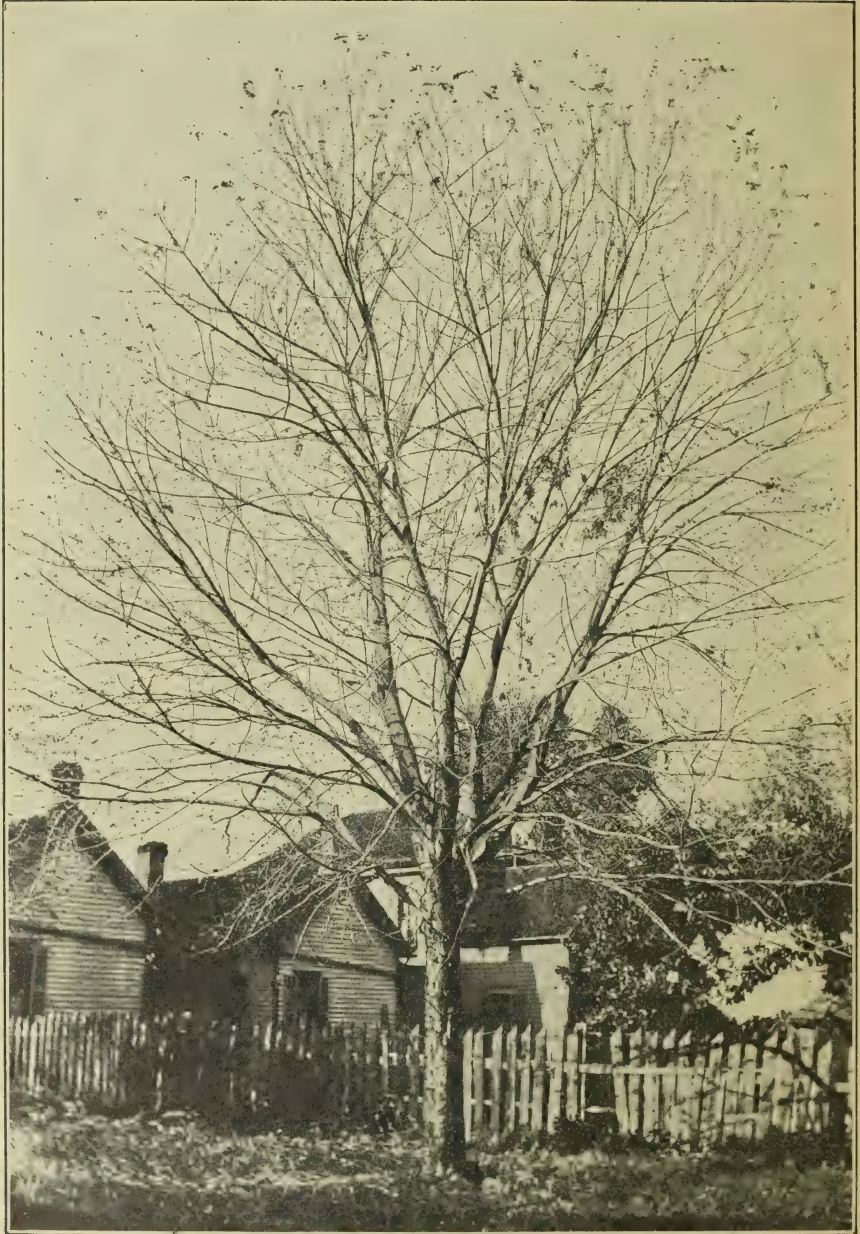


FIG. 2.—Maple tree at Kansas City, Kans., defoliated by green-striped maple worm. (Original.)

[Cir. 110]

many rows of large maples were entirely defoliated, rendering them very unsightly. (See fig. 3.) At about the same time Doctor Riley reported similar complete defoliation on the grounds of the State agricultural college at Manhattan, Kans., and of the State university at Lawrence, Kans. In 1901 Mr. F. E. Brooks reported great damage to the foliage of maple in the vicinity of French Creek, W. Va. Since 1905 the species has been abundant in portions of Maryland and Virginia, but not noticeably troublesome.

During 1908 it was devastating forests in and around Fryeburg, Me. At that time it almost entirely stripped maple and—it was said—oak, beech, birch, apple, and other deciduous trees over a very large section, but it seems probable that other species were present, as in other cases reported to this office.^a It was particularly troublesome to shade maples in Maine, New Hampshire, and Pennsylvania.

NATURAL ENEMIES.

The green-striped maple worm is frequently eaten by domestic fowls and by many birds. Of these the robin and yellow-billed cuckoo have been recorded by Bruner.^b He reports both of these birds as actively engaged in picking up and swallowing the “worms” as late as September 20, at Lincoln, Nebr. The bluebird, tufted titmouse, red-headed woodpecker, red-eyed vireo, and crow blackbird are also stated by the late Prof. F. H. Snow to eat the “worms,” while the moths also are sometimes destroyed by birds. To the above list Prof. F. E. L. Beal, of the Bureau of Biological Survey, adds the black-billed cuckoo and the great-crested flycatcher as enemies of this insect.

This species is parasitized by a common ichneumon fly, *Limnerium fugitivum* Say, a rather general parasite of lepidopterous larvæ. Two tachina flies have been reared from it, *Frontina frenchii* Will., from Washington, D. C., and vicinity, and *Belvosia bifasciata* Fab., from northern Missouri. Among the old Riley notes is a record of the rearing of an egg parasite, but the species has not been determined.

At one time the electric lights in some of the large cities mentioned were the means of attracting and destroying large numbers of the moths, and both moths and caterpillars were destroyed in large numbers by passers-by, who trampled on them.

As a rule little is to be expected from tachina flies as a means of controlling insect pests, and the ichneumon mentioned, being a general parasite, is not an efficient destroyer of this particular species. In

^aThe other species concerned in damage were *Heterocampa guttivitta* Walk. and *H. bilineata* Pack., principally to forest trees, although during the year they injured maple groves and attacked sugar maple and a considerable variety of the forest trees in New England.

^bLawrence Bruner, 1890, Bull. 14 Nebr. Agr. Exp. Sta., pp. 54-59.

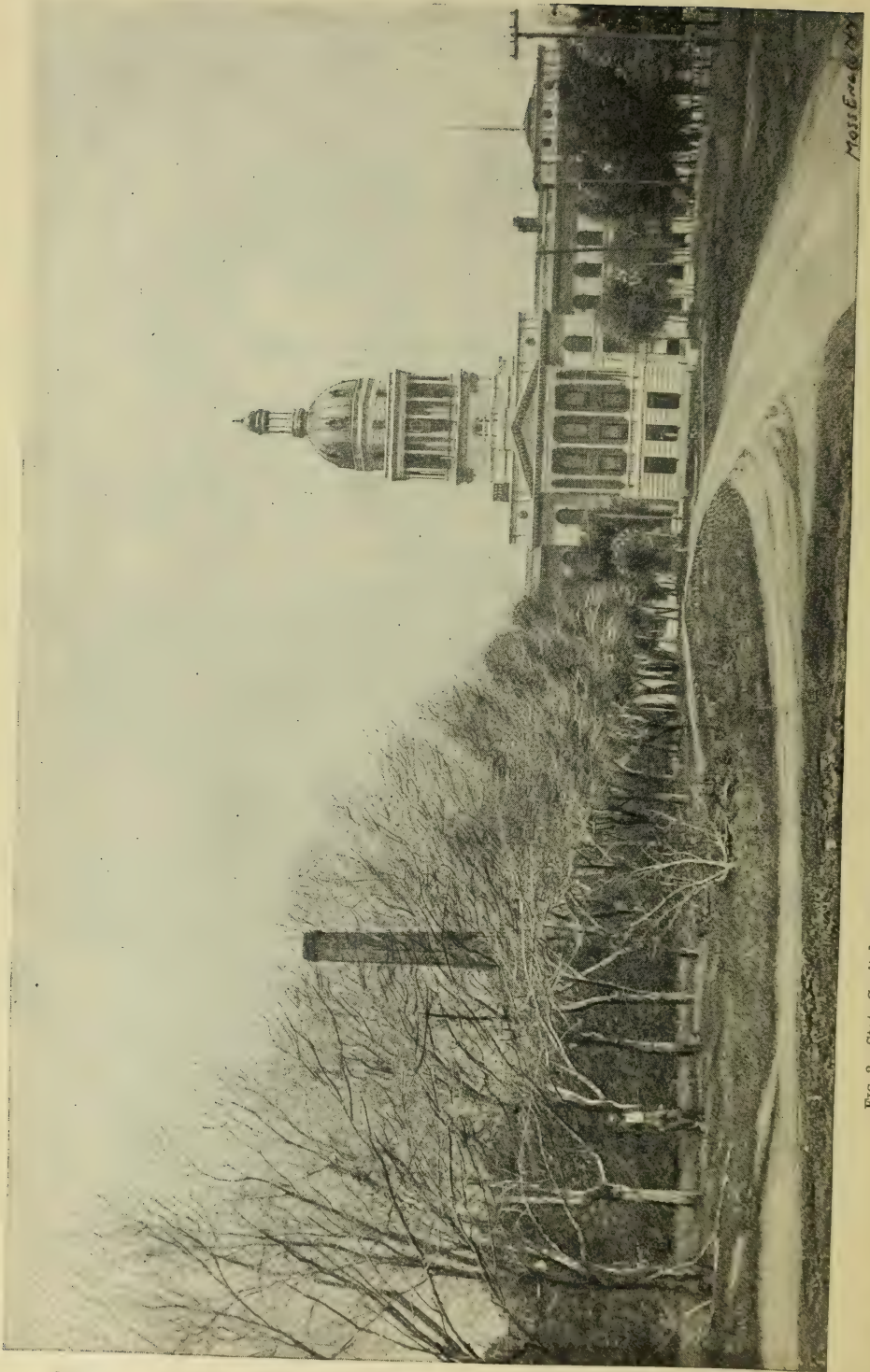


FIG. 3.—State Capitol at Lincoln, Nebr., showing trees defoliated in 1890 by the green-striped maple worm.

other words, we can not rely for assistance upon any of the natural enemies except birds. These should be encouraged in every possible way, and warfare should be waged against the English sparrow, which does not feed on this caterpillar, save perhaps occasionally in nesting time, and is a great pest in itself, especially as it drives other and useful birds from cities and towns.

REMEDIES.

Arsenicals.—Spraying with an arsenical mixture, if accomplished when the caterpillars are young, is the most effective means of controlling this insect, but a spraying is not easily applied when a large grove of maples is infested. Either Paris green or arsenate of lead may be used and applied in accordance with the directions furnished for other shade-tree defoliators, as described in detail in Farmers' Bulletin No. 99. This publication should be in the hands of all persons suffering from the ravages of shade-tree insects, and that portion relating to general instructions in the last chapter should be read.^a Paris green may be applied on maple trees as strong as 1 pound to 50 gallons of water, but half that strength, or one-half pound to 50 gallons of water, will probably suffice in most cases. Arsenate of lead may be safely used at as high a rate as from 2 to 4 pounds of the poison to 50 gallons of water.

Trenching.—If an arsenical spray has not been used while the larvæ are young, large numbers of the pests may be trapped and easily destroyed by digging a trench either around individual trees or around groves or belts of trees. The trench should be at least a foot deep, with the outer walls sloping under. The larvæ usually wander away from the trees before entering the earth, and will be caught in the trench in great numbers or will bury themselves in the ground in the bottom of the trench, where they can be killed. This remedy was given a practical and thoroughly satisfactory test many years ago by Doctor Riley, and has been recommended to our correspondents generally.

Hand picking.—When the public once becomes well acquainted with this insect in all of its stages, from the egg to the moth, large numbers of the eggs and the moths can be killed by hand on their appearance in May or June, and individual choice trees may in a measure be protected in this manner.

Approved:

JAMES WILSON,

Secretary of Agriculture,

WASHINGTON, D. C., May 26, 1909.

^a Farmers' Bulletin No. 99 is furnished gratis on application to the Department of Agriculture.

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